SKI Report 2007:23

Research

On Safety Management

A Frame of Reference for Studies of Safety Management with Examples From Non-Nuclear Contexts of Relevance for Nuclear Safety

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November 2004

ISSN 1104-1374
ISRN SKI-R-07/23-SE

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SKI PERSPECTIVE

Background

SKI has launched a three-year research project on safety management. In a pre-study to this phase of the project the authors introduced a system perspective on safety management. In that study two case studies of safety management related to a car manufacturer and a road tunnel system were presented. The case studies were presented from a system perspective and the emphasis was on information feedback from accident risks in the systems. Qualitative differences in safety management between the different case studies were reported and developed in the report.

Purpose

This report is the result of the next phase in the three-year project on safety management. The purpose of this study has been to establish a frame of reference for studies of safety management. This is done with examples from non-nuclear contexts of relevance, focusing on two regulators.

The study was meant to broaden the definitions of safety management and system theory. The aim was also to describe two regulatory organizations for two industries, offshore and commercial aviation, using the system perspective and having the organizations as examples in the building of the frame of reference. An earlier study of a car manufacturer was also added to this research project.

Results

The authors present the theoretical framework. There they also discuss the pros of using the system perspective to build a useful frame of reference of safety management using non-nuclear organizations; this as a way to create models useful for the nuclear power industry but based on general understanding of the concept of safety management.

The chosen organizations are used extensively to illustrate the concept of safety management. Some central themes for the analysis were organizational structure and policy, feedback systems, power-authority, competence, integrity and identified threats to safety.

The system theoretical framework has been developed and will be the subject for further development in the next phase of the research project.

In parallel with the empirical and theoretical studies the authors have participated in a Nordic network where participants from Sweden, Finland and Norway have shared their research concerning organizational safety, safety culture and safety management. This research project has been able to get valuable input from the network and also share experiences within the network.

Continued work

As mentioned above further studies are needed to develop a frame of reference for describing safety management across industries and activities. The collecting of data from different industries and activities which can illustrate high quality and perhaps poor safety management and how safety management can be improved will continue in the next phase of the three-year project. Of importance is to get input from empirical studies from operators.

Effects on the SKI regulative work

The results give emphasis to the importance of the field. The frame of reference for safety management described in the report is one that can, when fully developed, have the potential to be a support for SKI when choosing strategies to enhance the regulatory work on safety management.

Project information

SKI project coordinator: Lars Axelsson
Project number: 14.3-030300

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A Frame of Reference for Studies of Safety Management with Examples From Non-Nuclear Contexts of Relevance for Nuclear Safety

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November 2004

Summary

A good knowledge about safety management from risk technologies outside the area of nuclear power may contribute to both broaden the perspectives on safety management in general, and point at new opportunities for improving safety measures within the nuclear industry. First, a theoretical framework for the study of safety management in general is presented, followed by three case studies on safety management from different non-nuclear areas with potential relevance for nuclear safety. The chapters are written as separate reports and can be read independently of each other.

The nuclear industry has a long experience about the management of risky activities, involving all the stages from planing to implementation, both on a more generalized level and in the specific branches of activities (management, administration, operation, maintenance, etc.). Here, safety management is a key concept related to these areas of activities.

Outside the field of nuclear power there exist a number of different non-nuclear risk technologies, each one with their own specific needs and experiences about safety management. The differences between the areas consist partly of the different experiences caused by the different technologies. Besides using own experiences in safety practices within the own areas of activities, it may be profitable to take advantage in knowledge and experiences from one area and put it in practice in another area.

In order to facilitate knowledge transfer from one technological area to another it may be possible to adapt a common theoretical model, for descriptions and explanations, to the different technologies. Such a model should admit that common denominators for safety management across the areas might be identified and described with common concepts.
Systems theory gives the opportunity to not only create models that are descriptive for events within the limits of a given technology, but also to generate knowledge that can be transferred to other technologies. System theories could be developed to grasp both technological non-living systems and human living-systems. It is considered a strength to be able to describe both technological and human elements and their mutual relations within a common theoretical framework. In the ongoing project we have introduced a systems perspective in which both living systems and non-living systems can be described in terms of processes and structures. In the framework it is exemplified how system concepts may be related to concepts related to organizational theory.

Three different areas of operations are examined in the case studies: civil aviation, petroleum production, and car manufacturing. Two of the areas are represented by authorities: the Swedish Civil Aviation Safety Authority; and the Norwegian Petroleum Directorate. The third study is represented by a car manufacturer, Volvo. In order to study the interaction between authority and company, a Swedish airline company was investigated. In each case study, a thorough description of the organizational structure, the activities and operations, and the safety management specific for each organization, is given. In the descriptions, safety management within each area is studied in relation to concepts central to the system theoretical framework. Structural aspects of the system studied, system regulation, information feedback, and detection and identification of threats to safety, are some examples of concepts that are related to keep the system stable, concepts that also are related to activities that are often labeled as central to

safety management. Thus, the case studies generate both illustrative descriptions about the unique in the specific areas studied, both from an organizational and a safety perspective, and, furthermore, put this in relation to general system theoretical concepts that are possible to transfer across areas.

Each of the case studies generated detailed descriptions of the organization studied, activities and operations, and safety management for each organization respectively. The analyses are described and summarized in detail in each chapter. To summarize some general themes from the analyzes the following are important to mention:
-A distinct division of responsibilities for safety work between organizational units.
-A clear communication about the organization's safety policy and how each member of the organization is a part of the policy.
-Channels for information and information feedback are clearly represented in the system structure.
-Availability to incident reporting systems and the responsibility of each member of the organization to report incidents.
-The importance to differentiate between established structures for information management and established structures for information content.
-To make clear the range and meaning of power and authority.
-Identification of the organizations' competence and integrity in relation to safety management.
-The importance of identifying threats to safety, not only for company activities and operations but also for authority activities and operations.

In the next phase of the ongoing project, we wish to gain more insight in the companies' perspectives of safety management. The system theoretical framework outlined in this report will be used as a frame of reference for the analyses. We believe that the results from this and future studies in the project will give opportunities to take further steps towards improving safety in the nuclear power operations, both from a company and from a regulator perspective.

Sammanfattning

Goda kunskaper om *säkerhetshantering* (safety management) från riskteknologier utanför kärnkraftsområdet kan bidra till att både vidga perspektiven för säkerhetshantering generellt och peka på nya möjligheter till konkreta säkerhetsförbättrande åtgärder inom kärnkraftsindustrin. I denna interrimrapport presenteras först ett teoretiskt ramverk för studiet av säkerhetshantering generellt. Därefter redovisas tre kapitel med fallstudier om säkerhetshantering i olika icke-nukleära verksamheter med potentiell relevans för kärnkraftssäkerheten. Kapitlen är skrivna i form av separata rapporter och kan följaktligen läsas oberoende av varandra.

Kärnkraftsindustrin har en lång erfarenhet av hur man leder, fördelar och kontrollerar handhavandet av riskfyllda aktiviteter, allt ifrån planering till implementering, både på ett övergripande plan och inom de många olika verksamhetsgrenarna (ledning och administration, drift, underhåll, etc.). Säkerhetshantering är här ett viktigt nyckelbegrepp relaterat till dessa verksamheter och aktiviteter.

Utanför kärnkraftsområdet finns det en mängd olika icke-nukleära riskteknologier som var och en har sina egna specifika behov och erfarenheter av säkerhetshantering.

Skillnaderna mellan de olika områdena består delvis i de skilda erfarenheter som de olika teknologierna givit upphov till. Förutom att ensidigt omsätta sina erfarenheter i det egna verksamhetsspecifika säkerhetsarbetet så kan det ligga stora vinster i att försöka tillvarata kunskaper och erfarenheter från ett område och omsätta dessa inom ett annat.

För att underlätta kunskapsöverföringen från ett teknikområde till ett annat kan man försöka att anpassa en övergripande teoretisk modell för beskrivningar och förklaringar till de olika teknologierna. En sådan modell bör medge att gemensamma nämnare för säkerhetshanteringen områdena emellan kan identifieras och beskrivas med gemensamma begrepp. Systemteorin erbjuder en möjlighet att inte enbart skapa modeller som kan beskriva händelser inom ramen för en given teknologi, utan dessutom generera kunskaper som är möjliga att överföra till andra teknologier. Systemteorier kan vara utvecklade till att både kunna omfatta teknologiska icke-levande system och mänskliga levande system. Det är en styrka att kunna beskriva både tekniska och mänskliga element samt deras inbördes relationer inom samma teoretiska ram. Inom ramen för det pågående forskningsprojektet har vi introducerat ett systemperspektiv där både levande system och ickelevande system kan beskrivas i termer av processer och strukturer. I detta ramverk exemplifieras hur systembegrepp kan relateras till begrepp med anknytning till organisationsteorier.

I fallstudierna granskas tre olika verksamheter: civilflyg; oljeproduktion; och biltillverkning. Två av områdena är representerade av myndigheter: Luftfartsinspektionen; och det Norska Oljedirektoratet. Den tredje studien representeras av en biltillverkare, Volvo. För att beskriva interaktionen mellan myndighet och bolag studerades även ett svenskt flygbolag. I samtliga fallstudier görs en noggrann beskrivning av organisationsstrukturen, den specifika verksamheten och säkerhetshanteringen. Vid beskrivningarna studeras säkerhetshanteringen inom respektive verksamhet i relation till centrala begrepp i det systemteoretiska ramverket. Strukturella aspekter av det studerade systemet, styrning och reglering av systemen, informations återkoppling, och upptäckt av hot mot säkerheten, är några exempel på viktiga begrepp som är relaterade till att bibehålla systemet stabilt, begrepp som också är relaterade till aktiviteter som ofta betecknas som centrala för säkerhetshantering. Fallstudierna genererar därmed både illustrativa beskrivningar av det unika i de specifika verksamheterna, både ur ett organisatoriskt och ett säkerhets perspektiv, samt sätter detta i relation till generella systemteoretiska begrepp vilka är överförbara verksamheter emellan.

Var och en av fallstudierna genererade detaljerade beskrivningar av respektive organisation, dess verksamhet och säkerhetshantering. Analyserna återfinns beskrivna och samanfattade i respektive kapitel. För att sammanfatta några generella teman från analyserna är följande viktigt att nämna:
-Tydlig ansvarsfördelning av säkerhetsarbetet mellan organisatoriska enheter.
-Tydlig kommunikation av organisationens säkerhetspolicy och hur varje medlem i organisationen delaktig i policyn.
-Kanaler för information och informationsåterkoppling av information tydligt representerade i systemstrukturen.
-Tillgängligheten till incidentrapporteringssystem och varje organisationsmedlems ansvar att rapportera incidenter.
-Betydelsen av att skilja på etablerade strukturer för informationshantering och etablerade strukturer för informationsinnehåll.
-Att konkretisera omfattning och innebörd av myndighetsutövandet och auktoritet.

-Identifiera organisationernas kompetens och integritet i relation till säkerhetshantering.
-Vikten av att identifiera hot mot säkerheten i den egna verksamheten, inte enbart för bolagen utan även för kontrollmyndigheten.

I nästa fas av det pågående projektet, önskar vi uppnå en ökad insikt i säkerhetshanteringen från ett bolagsperspektiv. Det systemteoretiska ramverket presenterat i denna rapport kommer att användas som en referensram för analyserna. Vi tror att resultaten från denna och framtida forskning inom projektet kommer att erbjuda möjligheter till säkerhetsförbättrande åtgärder inom kärnkrafts relaterade verksamheter, både från ett bolags- och från ett myndighetsperspektiv.

CONTENTS

1. Introduction

The purpose of the present study is to provide a theoretical framework and use this when presenting case studies of safety management from non-nuclear contexts to the benefit for safety management in the nuclear power sector. There will be two case studies of regulator organizations and one about a regulated organization. Although the case studies define the foci of attention, corresponding regulated industry/activity and regulator will also be mentioned when necessary for the analysis.

The case studies are written in a form that they "stand alone" and can be sampled according to the interest of the reader. This means that there will be some overlap between the introductions.

There are a number of definitions of management and safety management (Salo and Svenson, 2001). In the present context we will start using the following general definition: " safety management is a process in which a producer, societal representatives and the public interact in finding a balance between the benefits, costs and risk of a product, an activity or process". The goal should be to find a balance, which is the best for most of the people in the society and at least acceptable for everybody. Safety management is executed as subprocesses at all levels of an organization.

Recently, actors in the nuclear power domain have shown interest in how other industries are regulated and how the manage regulation. To exemplify, the Nordic organization for cooperation about nuclear power safety, NKS commissioned the report "Safety- and risk analysis activities in other areas then the nuclear industry" (Kozine, Duijm and Lauridsen, 2000). This report presents legislation concerning industries posing major risks to the environment and population. The analysis was mainly based on existing document, many of which could be related to the Seveso II directive. The report covers methods for assessing risks and determining levels of acceptance. The methods can be quantitative (e.g., PRA, probabilistic risk analysis) or a combination of numerical and qualitative (ALARP, as low as reasonably practicable).

The report does not go into detail about risk management beyond general considerations, such as, risk policy should be transparent, predictable and controllable, risk policy should focus on the largest risk, risk policy should be equitable, human errors should be taken into account and proper risk analyses have to be conducted. There is, however one more detailed account of criteria for qualified risk management cited in the report, and that is the citation from Environment Canada. The criteria are defined from an industry perspective and take costs, risk reduction effectiveness and public acceptance into account. It is important to stress that risk perception plays an important role when levels of acceptable risks are suggested or required.

Recently, Lindblom et al. (2003) under the supervision of Sven-Ove Hansson have given a comprehensive overview of 8 regulators in Sweden. The authors describe differences in inspection policies and practices. To exemplify, the definitions of supervision and inspection vary between regulators, there are great variations of inspection policies in terms of frequencies of inspections and resources devoted to inspections and there are also differences concerning notification or not before inspection.

On the international scene, safety management has also become a very important area of investigation. This can be exemplified by the OECD/NEA:/CSNI/R/ SEGHOF Group who treats safety management on a regular basis and which has taken the initiative to a workshop on scientific approaches to safety management (NEA/CSNI, 2003).

In an earlier report, Svenson and Salo (2003) outlined a system approach of describing human-technology-organizational systems like a nuclear power plant and its regulators. Based on this framework, the present contribution will further develop this perspective on safety management. The present report first gives an elaborate case study analysis of safety management of a regulated industry (a car manufacturer - based on several interviews, site visits and documents – earlier introduced by Svenson and Salo (2003). The report also gives an analysis of safety management of a regulator (a civil air traffic regulator - based on site visits, several interviews and documents). Finally, there is a presentation of safety management in another regulator (a regulatory authority of offshore oil industry, - based on an analysis of documents recommended by the authority through a contact with the regulator and a person responsible for safety).

2.Background

2.1 The system approach

In this section we will present a theoretical framework that can be used when suprasystems, such as a nuclear power plant, consisting of subsystems that are both living (e.g., a person, the organization) and non-living (e.g., the technical systems of the plant). Following this, we will then link concepts from organizational management and safety management to the framework. The introduction of chapter 3 will give further references to general systems theory including references to Bertalanffy. One early example of a system approach to management was given by Katz and Kahn (1978) who modeled organizations as transformation systems with transformation processes (day to day activities), organizational control processes (monitoring the system) and an infrastructure needed for the transformation process (structures, processes and technology).

Living systems, such as, an organization exist in space and consist of matter and energy that are organized by information. Living and non-living systems can be described in terms of *structures* and *processes*. The processes are governed by information and driven by energy. If we want to study a process, we have to define a structure including the primitives (smallest units) that we want to use. In other words, a process is always observed through changes in structure. (The primitives could also be processes and in this case the structure would concern the structure of processes.)

Correspondingly, we cannot describe a structure without a process to map the structure. To exemplify, if we want to understand the structure of attitudes of the people working in a nuclear power plant, we ask them to process the information of a questionnaire and to give us an output on paper, that we in turn can process to reach a conclusion about the structure of attitudes.

Systems often form hierarchies with suprasystems containing subsystems. As mentioned in the introduction, a nuclear power plant or any other industry/human technology activity can be modeled as a suprasystem with two subsystems on the next lower level. The subsystems interact to keep themselves and the suprasystem in a steady state when it performs what it is intended to produce, e.g., electricity. But also in other steady state conditions, e.g., when the systems enters outage, stays in outage and when it is started again.

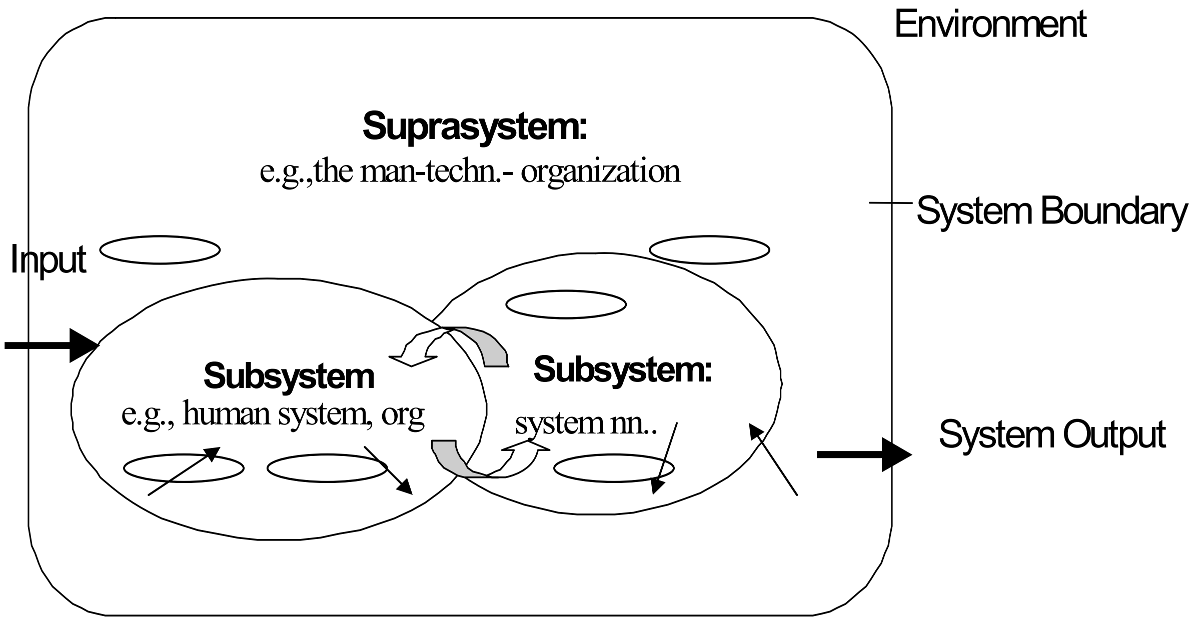

Figure 2.1: A schematic illustration of the structure of suprasystem and subsystems with process arrows of flows of information, matter and energy.

What we call a plant or an industry consists of one subsystem, which is a concrete constructed, technical non-living system and another other subsystem, which is the organization of people constituting a concrete living system (cf., Miller, 1978). The purpose of the organization is to keep the suprasystem, including the technical and the organizational systems and their subsystems, within the limits of a steady state when producing electricity at a rate determined by other suprasystems (e.g., economic and political systems).

That is, managing the suprasystem so that it is kept in a steady state with the all the variables within the range of stability prescribed by that steady state. If this is not done, the system's structures and processes change, and the system moves towards another steady state. In this change the system may even have difficulties to survive, but ideally it should adapt to the new environmental requirements.

"A system is adjusted to its suprasystem only if it has an internal purpose or external goal which is consistent with the norm established by the suprasystem " (Miller, 1978, p.40) and therefore it is interesting to know to what extent the subsystems making up a nuclear power plant or any industry comply with the suprasystem and how they achieve it.

If one of the variables moves towards the limit of stability, the system strives to counteract the movement through negative feedback. This is normal regulation of the system. Both the plant technical subsystem and the organization subsystem have lower level subsystems and some of these have the purpose of keeping variables within their ranges of stability. Figure 2.1 is an attempt to visualize supersystems and subsystems at different levels.

Threats to the stability of a system appears when the system is exposed to stresses threatening to move its variables outside the range of stability and the system out of its steady state. Then it is important that adjustment processes keep the variables within their ranges of stability despite the stresses. In this situation, special subsystems (e.g., barrier function systems, Svenson, 1991, 2001) are activated to preserve the steady state of the system. Barrier function systems are a kind of subsystems performing processes with the purpose of retaining a system within a steady state even under stress. If one barrier function system cannot handle the situation there are usually other backup systems (often called defense in depth). In a nuclear power plant, the organization and the plant are designed so that for most threats, other barrier function systems are activated to keep the suprasystem in a stable steady state. In living systems, such as humans there are normally so many coupled adjustment processes that the system can be called ultrastable (Miller, 1978, p. 36).

Adjustment processes rely on negative feedback with the purpose of decreasing the deviation of a variable from the steady state of a particular variable and there are different kinds of negative feedback used to keep a system in a stable steady state. Among these one finds the following that are interesting for safety management and will be followed up later.

(1) *internal feedback* with a feedback loop that never crosses the boundary of the system (e.g., temperature control functions in mammals). The interior of the organization of a nuclear power plant is full of such feedbacks on all levels.

(2*) external feedback*, which goes outside the boundaries of the system receiving input from other systems (e.g., legal action against a system). This includes all input from the outside that can be interpreted as responses to the behavior of an industry, owner reactions, public opinion, market reactions political, reactions etc.

(3*) output feedback*, where the output regulates the output at a steady state level (e.g., rate of production). This is a feedback that can be used to achieve goals determined by other feedbacks and strategies (e.g., constant production to save energy or to keep a price high and stable).

(4) *input signal feedback* uses the input to regulate the input (e.g., if too much information reaches the system the information can be buffered or slowed down). It also covers more material things, such as of how much is kept in stock by a company etc

(5*) passive adjustment feedback,* which reaches a steady state through altering environmental variables (e.g., the system of a heater controlled by a thermostat that cuts off power when the environment has reached a certain temperature). This is a very important kind of feedback because it involves changing the environment, e.g., in terms of legislation, attitudes etc. The feedback can be executed in the form of physical change of the environment, research, advertising, influencing the media, lobbying, bribing etc

Loose feedback is a feedback that permits errors or marked deviations from the steady state before corrections are initiated. The opposite is *tight feedback* with a feedback loop that is quick and immediately corrects a deviation. It has been shown repeatedly that humans have great problems, in particular when they control dynamic systems with delayed feedback.

Adjustment of a system to its environment or interrelated systems can also take place through *changes in the system itself* in terms of its structures and internal processes. All adjustment processes have their costs. The costs of changing a system can be in terms of information, energy, material, money, time etc and scarcity may affect how close to the goals the system can operate.

Optimal resource allocation processes are essential in all system management including safety management. Note that optimal does not mean maximal resource utilization because there must always be resources in reserve when the system is threatened. Living systems have adapted resource allocation admiringly well in their normal natural environments. However, when the environment changes drastically and the systems are not prepared for this, the systems may become exposed to serious threats and have trouble with, for example, information overload, system resource scarcities and improper output. This perspective may also apply to the individual operator or group of operators as subsystems in safety management of an industry.

Power represents one system's ability to control another system at the same or at another level. Power and control is initiated, carried out and terminated through a sequence of information exchange. A system transmits a message or command signal to another system and there are a number of specific characteristics of such messages. The message has an address (receiver), a signature, contains evidence that the transmitter is legitimate, expects compliance and the message specifies an action the receiver is expected to carry out. Almost all communication within an organization can be seen in a perspective of formally defined and informal power. The relationships between a regulatory body and a regulated industry should illustrate such a relationship. *Competence of power* is essential for keeping a system in a stable state or for changing the system safely from one stable state to another.

As mentioned above the purpose of a nuclear power plant system is to remain in a preferred steady state that is partly defined by external rewards and punishments and partly by internal factors. One kind of external goals of a nuclear power plant system is to produce electricity as cheaply as possible. Another kind of goals are safety management goals. Such a goal can be to operate the plant more safely than the year before, another goal that the plant should be safer than other plants. Or there may be the goal to fulfill regulator safety regulation without improvements or increased safety in comparison with the officially required safety levels.
The two kinds of goals (production and safety goals) sometimes coincide and sometimes they are antagonistic.

Adequate management in a supersystem and its subsystems implies that adjustment and feedback functions are maintained so that the plant remains in a steady state during its life time, even under conditions of threat and stress.

2.2 Safety management and the system approach

2.2.1 The general and policy levels

On the suprasystem level, management is a process in which a producer, societal representatives and the public interact in finding a balance between the benefits, costs and risks of an activity or a product (Svenson, 1984). "The goal of this process should be to find a balance, which is best for most of the people in a society and at least acceptable for everybody" (Svenson, 1984, p. 486). The balance is reached through a number of feedbacks between the agents in this process.

Generally speaking, safety management entails the establishment of a management process committed to determining the threats to a system or its environment, the risk level of a particular activity or product, and instances in which deviations from normal or desired processes can be associated with risks. The safety management process of high socio-technical activities, such as those in the process industry or in a transportation system, addresses issues of how to cope with the complexity of all of the factors, which are relevant to management and regulation (cf., Hale, Heming, Carthey and Kirwan, 1997). Hale and his co-authors (1997, p.121), also emphasize the dynamics of safety management as a process, they want to consider safety management "as a set of problem solving activities at different levels of abstraction in all phases of the system life cycle".

Safety in a risky activity/industry can be given different roles. To exemplify, (a) an organizational system can treat the external feedback of minimum safety levels (c.f., societal regulating authority rules and legislation) as *limiting conditions* within which the organization is free to behave. No deviations outside the permitted limits are allowed.

It is also possible to (b) treat the external minimum safety level feedback as information also about the *costs of behavior in violation of the safety limits*. For example, an organizational system may calculate the costs of following the safety limits, the gain of exceeding the limits, the probability of detection and the penalty of doing so if detected. Then the organization may find that the expected value of not following the external safety limits is greater than if they are followed and decide to violate the safety rules in a trade off decision. Alternatively, it is also possible for the system to find that safety violations are detected with such a probability and cost so much that it is economically wiser to introduce more strict internal safety limits than regulated to insure against big losses (production losses, material losses, economic losses etc).

There is also a possibility (c) to use external safety limits as a *parameter of competition*. Then the external safety limits are seen as the first steppingstones towards system safety levels that are stricter than those imposed externally. This presupposes that there is or a "market" (reputation, economy, influence etc) is created for safety. In this case the organizational system could influence societal external safety limits so that they become even stricter, forcing competitors to comply.

However, it is also (d) possible that an organization attempts to *influence the external safety limits* e.g., negatively towards more lax levels (through e.g., lobbying, economic threats, moving a factory).

The management literature is quite diverse and different authors use their own perspectives that often differ widely from each other (Salo and Svenson, 2001). However, there seems to be some concepts that are fairly general and that can be translated into living systems terms. One advantage of interpreting the management concepts into living systems terms is that the living systems perspective can create a meta perspective avoiding the use of only one or the other approach to management. Therefore, Table 2.1 lists a number of concepts from the management literature and relates them to systems terms.

The table gives a sample of rather general concepts, some of which will be further elaborated when the focus becomes safety management. In addition to the different kinds of feedback and goals presented earlier, the description of an organization, the organizational behavior, maintenance and health care, power, leadership, safety culture, organizational learning, reactions to incidents and accidents, quality assurance, market reactions including societal regulation and lobbying are of interest in studies of safety management.

Table 2.1: Examples of concepts in the safety management literature and living system theory.

Management	**Systems**
1. Description of human-technology organization	System description with boundaries **Structure**
2. Goals	Goals **Structure**
3. Organizational behavior	The external output and internal reactions of a system, often at the macro level **Process**
4. Long term survival of organization	Resilience of system **Process: Long time perspective**
5. Maintenance and health care	Repair **Process**
6. Power	Power **Structure**
7. Leadership	The way power is executed by the decider at different levels (individuals and groups of individuals) **Process**
8. Attitudes	Characteristics of the subsystem of individuals assumed to affect the output of the subsystems **Structure**
9. Organizational culture	Characteristics of the subsystem of individuals in a group in terms of attitudes, behaviors etc. that are generally shared. **Structure (also including structure of processes, e.g., habits)**
10. Safety culture	Characteristics of the subsystems of individuals in a group in terms of attitudes, behavior, etc that are generally shared and specially related to avoid, stop or ameliorate events disturbing the system on different levels. Includes disturbances to the environment of the system. **Structure (also of processes)**
11. Organizational learning	Signifies how a system memorizes its earlier history and its adjustments to internal and external changes **Process**
12. Reactions to incident and accident investigations	External feedback **Process**
13. Quality assurance	Internal feedback on monitoring of output **Process**
14. Organizational effectiveness	The ratio of matter/energy produced to the goals of the system and matter/energy used per time unit. **Process: Short time perspective (may lead to vulnerability in long term perspective)**
15. Time sharing functions, buffering	Input signal feedback **Process**
16. Slow delayed reactions of system internally and externally	Loose feedback **Process**
17. Fast close reactions of system internally and externally	Tight feedback **Process**
18. Market reactions, information, regulation from society	External feedback **Process**
19. Constant production	Output feedback **Process**
20. Lobbying, buying out competitors	Passive adjustment feedback change of environment **Process**

Some of the concepts in Table 2:1 will be dealt with in some detail below.

2.2.2 Successful safety management: on some prerequisites

In the following, we will treat some prerequisites that must be met to enable successful safety management in an organization. The arguments presented hold both for the regulator and the regulated organization. In the regulator organization the conditions concern most of the organization and for the regulated organization, the subsystems responsible for planning, deciding and implementing the management of safety as well as those implementing safety management down to the lowest echelon. Successful safety management requires *power*, *competence* and *integrity* of the management process at each level of an organizational hierarchy. If these conditions are not met, this means that there are obvious threats against safety.

Power or authority is needed if safety measures should not remain just good intentions or not implemented policies. Power means that the safety management systems should be able to carry through safety policies and plans in an organization. Threats against this prerequisite for safety management can be economic pressure on profitability or a decreasing trend of safety awareness among the people working in the organization.

Competence and expert knowledge about an organization's activities/industrial processes, its risks and safety issues is necessary not only in the safety management subsystems, but also at every higher level in an organization including the top level and the owners of the activity/industry. To exemplify, if top management of an industry does not have sufficient knowledge of the technicalities of the industrial process and its risks, there may be communication problems within the organization between top management and those who are responsible for safety. There may also be difficulties in communicating e.g., how to interpret the goals of safety and profitability to the employees in the industry.

Competence is an important variable in the interaction between the regulator and the regulated organization. A prerequisite is that the regulator has sufficient knowledge - knowledge at the same level or higher than those employed in the industry - about the activity/industry regulated. If the regulator does not have sufficient knowledge, there are risks associated with this. To exemplify, there are the risks that the regulation becomes inefficient and that the regulation becomes directed towards less important aspects.

Integrity means that people working with safety must work for safety and not be affected by other agents with other goals. When safety management is implemented the trade off between safety and other goals should be clear to everybody in an organization. This holds both within an organization and in the interaction between regulator and regulated organizations. To exemplify, lobbying and bribes are two obvious means of threatening the integrity of management in general as well as safety management. Of course, there are many other, more discrete and subtle processes that can threaten safety management.

2.2.3 On safety culture

In an attempt to get an overview and an indicator of the safety of an organization, the concept of safety culture was invented. Safety culture has become a popular and fruitful concept in safety management (Salo and Svenson, 2001). In systems term it is a characterization of a human organizational system controlling and interacting with a technical system. In a working document, Daniels, Merry, Rycraft, Ryser and Dahlgren (2003) suggest that attributes signifying safety culture can be grouped in five dimensions (1) safety leadership is clear,(2) safety is learning driven, (3) accountability for safety is clear, (4) safety is clearly recognized as a value, and (5) safety is integrated into all activities.

The attributes (e.g., priority of safety, view of mistakes) can be used to describe the safety culture profile of a particular organization using a lower level description than the top level of the five basic dimensions. Safety indicators (of attributes) can be assessed through using questionnaires, interviews and field studies of an organization. Safety culture can be measured through a mix of attitudes, beliefs and actions.

When actions are included in the safety culture concept, there is always a risk of problems with separating dependent and independent variables. A (severe) incident may be interpreted either as an indictor of (a poor) safety culture or the incident may be at least partly caused by (a poor) safety culture. One way of solving this is to use dynamic system modeling where the same variables appear as both dependent and independent.

Even though, the safety culture concept is well founded in the nuclear safety context, it is not easy to validate in that industry because accidents are so rare. Therefore, indirect evidence based on an incident before accident model can be used. In such validations, safety culture should be measured independently of the incidents that are used as criteria. We shall relate to this kind of reasoning in the next paragraph with a few comments on incident investigations.

2.3.4 On incident investigations

The basic assumption behind reports and analyses of incidents is that they relate in a regular way to the risk of an accident and accident frequency. To illustrate, for each set of 1000 severe accidents there may be on the average one real accident. This is what van der Schaaf and others call the "ratio hypothesis" (Wright and van der Schaaf, 2003). That is the ratio of accidents to incidents stays constant over time. However, there is no a priori reason to assume that the contributing causal factors in a dynamic systems interaction stay the same over time. The contributing causal factors may not be the same for an accident as for an incident (that is, what in this context has been called the common cause hypothesis). If they are not the same, then activities to prevent frequent incidents may not be the optimal cure also preventing more serious accidents. To conclude, although frequency can be empirically related to severity, this is not always true and needs to be shown in each particular case.

All incident analyses are also founded on more or less explicit mental or formal for capturing possible contributing factors of potential accidents. These models should be adequate for explaining an incident in relation to the potential risk it poses to the system under study. In the nuclear power safety field probabilistic risk analysis provides the main model for integrating incidents into an understanding of the technology of a plant.

However, contributing factors of a human factor organizational character cannot rely on a corresponding model for interpretations of incidents in terms in what might contribute to later accidents. Therefore, it is of particular interest to understand how incidents are described, integrated with technology and explained in terms of contributing human factors of both an active type (commission) and a passive type (errors of omission, failing barrier functions etc).

This was investigated by Salo and Svenson (2003) in a study of incident reports in the Swedish nuclear power industry, which is appended to this report. The results showed that majority of the reports described incidents in simple one or two step causal models including both human factors and technical subsystems components. All incidents took place in an organizational technology system consisting of a number of hierarchically ordered subsystems and components. In such a system conditions and events including events lower in the hierarchy may depend on the conditions and actions on higher levels. Therefore, contributing factors to an event from higher levels can also affect other subsystems on the same level as the system in focus in an event report. Thus, changes on a higher level may be more efficient, because of the added generic effects on other systems as well. However, this is valid only under the assumption that an incident is a valid precursor of an accident, a theme that was just elaborated.

The case studies presented here concern the regulator of the Swedish Civil Aviation Safety Authority - Luftfartsinspektionen regulating civil air traffic, the Norwegian Petroleum Directorate, Oliedirektoratet regulating the oil industry and Volvo Car corporation before it was taken over by Ford. After the presentation we will offer a discussion covering interesting aspects of safety management in these organizations that are judged relevant for the nuclear power industry and its regulators.

As was clear from the beginning of this study, management is a multifaceted process and therefore it is impossible to cover all aspects of safety management. Therefore, the case studies below will be organized around three 5 themes: (1) description of organization, (2) strategic safety philosophy, (3) internal and external feed back processes, (4) adaptative changes in interactions with the environment and (5) interaction with regulators of the risks.

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3. Safety management in Luftfartsinspektionen – Swedish Civil Aviation Safety Authority

This study applies the system approach in an analysis of a regulating authority, the Swedish Civil Aviation Safety Authority-SCASA (Luftfartsinspektionen). In the same way as the study of the car manufacturer in the former study, the present study is presented as a "stand alone study". This means that the text permits a reader to read this section without having covered the earlier sections.

3.1 Introduction

Humans have always been concerned about their safety. While unsafe human behavior contributes to 90% of all workplace accidents and incidents, this behavior also defines the course of safety development (Hollnagel, 1993 as cited in Cox, Jones and Rycraft, 2002). However, "... 'safety is no accident', not only because safety is by definition the absence of accidents, but also because it is not merely 'by accident' that safety is achieved. Somebody has to work at it!" (Tench, 1985, p.xi). Indeed, safety has to be managed, which entails the establishment of a management process committed to determining both the risk level of a particular activity or product, and instances in which risks are modeled as deviations from normal or desired processes (Hale, Heming, Carthey and Kirwan, 1997). The management process addresses issues of how to cope with the complexity of all of the factors which are relevant to the management and regulation of a high sociotechnical activity, such as in the process industry or a transportation system. This process of management is often referred to as safety management which, according to Svenson and Salo (2003) becomes a part of the overall management, defined as "...a process in which a producer, societal representative and the public interact in finding a balance between the benefits, costs and risks of an activity or a product". "The goal of this process should be to find a balance which is best for most of the people in a society and at least acceptable for everybody" (Svenson, 1984, p. 486). Hale and his co-authors (1997, p.121), who also emphasize the dynamics of safety management as a process, see safety management "as a set of problem solving activities at different levels of abstraction in all phases of the system life cycle".

Although concern about the introduction and the danger of the new technology is not new, the pace of technological change is increasing as the systems become more and more complex, it would either increase the potential for the occurrence of accidents or worsen the consequences. Humans and industries have learned to cope with and protect themselves from the natural forces that used to cause the majority of accidents. Man-made systems have now taken their place (Leveson, 1995).

Complex sociotechnological systems such as a nuclear power plant, or the aviation and petroleum industries, are examples of systems in which safety has to be managed in an effective and efficient way. A 'system' refers to a set of components acting together as a whole to achieve some common goal, objective or end (Leveson, 1995). Effective management is imperative to the avoidance of organizational accidents, and other catastrophic, albeit rare, events that can occur within such complex, modern systems (Reason, 1997). The aviation industry possesses great resemblance with the nuclear power industry, also being a complex sociotechnological system in where an accident could have disastrous effects not only to the individual, but also to the subordinate society and to the environment. The nuclear power industry also uses similar methods in incident/accident analysis as well as having great familiarity with the concept of safety management.

Despite the importance of safety management, more initiative has been directed toward the improvement of technology than to the improvement of safety management within technological systems (Martin, 2002). It must be understood that technological development and the safety management of technological system cannot be handled separately. However, researchers today have universal acceptance of the significant impact that management and organizational factors have over the safety of complex industries such as the nuclear industry and aviation (Martin, 2002). It is also believed that the interaction between 'hard' and 'soft' sciences, in other words, the interaction between man, technology and organization is an important factor contributing to the success of safety management. It is now generally assumed that most accidents on the job are the result of human error, and that these errors are the result of carelessness and incompetence. Investigators, however, are discovering that this assumption is a fallacy, and that humans are the last link in the causal chain of a given accident (Transport Canada, 2001). Although one may argue that humans are the first link, having constructed and developed the technology and devised the operational activities, various authors refute this claim. These authors (as cited in Martin, 2002, p.11), assert that there are today a held view that any significant accident will always be an organizational accident, "i.e. the multiple failures or error involved in the accident are only symptoms of organizational and management latent deficiencies that went undetected or uncorrected".

Evident by the impact of safety which organizational factors have, the relevance of safety management is certainly an important subject matter. Huge accidents and catastrophes are a part of every day life all over the world. The Three Mile Island accident and the meltdown at Chernobyl are just a couple of examples of such catastrophes. It is events like these that have contributed to the recognition of the importance of management as it might relate to safety (Sorenson, 2001), and to the subsequent attempts to prevent such disasters through the development of safety management.

Currently, due to unprecedented financial hardship, the subject of safety management is particularly important to the aviation industry. With a market that was never before so unstable, significantly increasing economic pressure on managers and external threats, it is even more important to focus on safety maintenance and improvement practices and ensure that they are not overwhelmed by economic concerns.

To provide an understanding of theoretical reasoning behind the present study, it will begin by presenting a general system theory, followed by an outline of organizational theories and behaviors. It will then put forward some theoretical and currently used regulatory strategies in the nuclear industry, and seek to summarize the material collected from the qualitative interviews, and finally, the study will suggest how the SCASA needs to improve its safety management in an already relatively safe activity.

3.1.2 General system theory

Ludwig von Bertalanffy (1973, p. 124) noted that, “modern science is characterized by its ever-increasing specialization, necessitated by the enormous amount of data, the complexity of techniques and of theoretical structures within every field. This, however has led to a breakdown of science as an integrated realm: The physicist, the biologist, the psychologist and the social scientist are, so to speak, encapsulated in a private universe, and it is difficult to get word from one cocoon to the other.” This statement summarizes von Bertalanffy’s opinion of certain limitations of science in coping with complex systems. Von Bertalanffy came to a notion of a general system theory as an elucidation of handling systems (Ruben *and* Kim, 1975), though science is presumably still facing the ‘cocoon’ phenomena. Along with Bertalanffy’s notion of a general system theory, Miller (1978) saw similar complications in his studies of living systems and their characteristics. He emphasized that any system, be it social, technical, living, or non-living, can be modeled as a suprasystem consisting of various subsystems. The interaction of the subsystems ensure that the suprasystem remains in a steady state when it performs what it is intended to produce, a safe aviation industry. The steady state, in this particular activity, is characterized by the system’s ability to keep the system in such way that it provides safe civil aviation. The development of systems theory began in the 1930’s and laid the foundation for a new way of dealing with complex systems (Leveson, 1995).

Arguably, any system characterized by its industry/human technological activity can be modeled as a suprasystem in which two subsystems interact. In one possible composition, the suprasystem can be described as the total activity of air transportation and corresponding ground activities. The ground crew, maintenance, security, the Air Navigation Services Division (ANS) and the Swedish Civil Aviation Administration, SCAA (Luftfartsverket-LFV), exemplify such activities. The subsystems, then, constitute the SCASA and the airline companies- the market (see figure 3.1). These systems can be further divided into technological non-living systems and living systems constituting the organizations and its members.

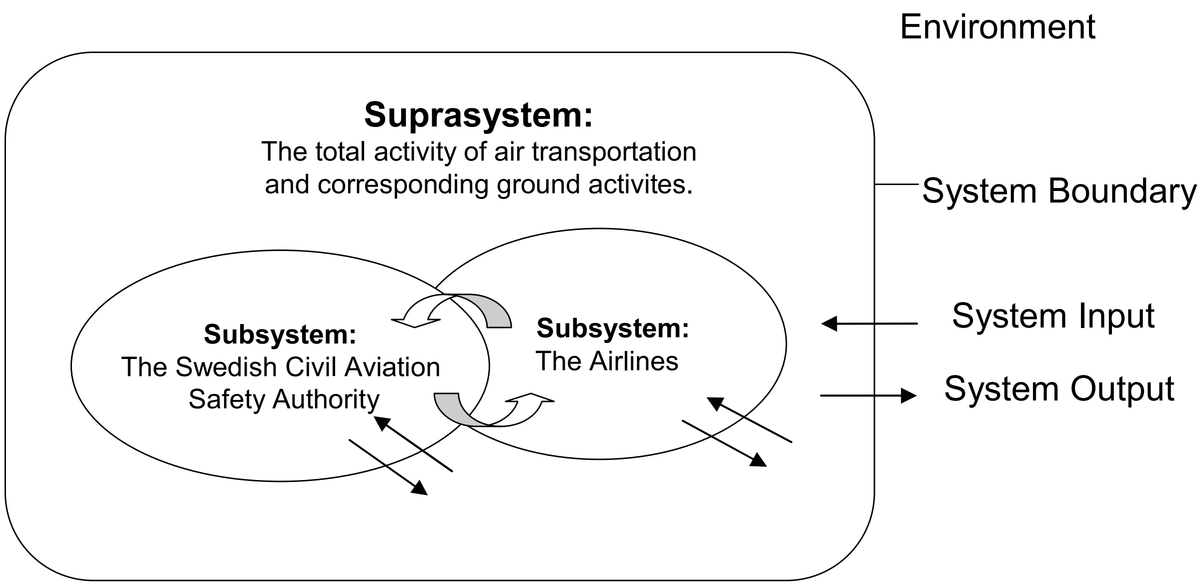


Figure 3.1: Based on Leveson’s (1995) definition of a system, the figure illustrates the interaction between the suprasystem and the subsystems, input and output.

However, this is only one possible composition, and in other constellations, the suprasystems could be defined as the International Civil Aviation Organization (ICAO) in which other subsystems, economic and political, interact.

If the market is exposed to stresses that threaten to move certain variables outside the range of stability, or to a situation in which the safety of the system is threatened, adjustment processes keep variables within their ranges of stability despite these stresses. However, when such situations occur, special subsystems such as technological and human barrier function systems are activated to preserve the steady state of the system (Svenson, 1990). Regular inspections of the system and preventative regulations can serve as such barrier functions. According to Svenson and Salo (2003) these adjustment processes rely on negative feedback in various forms: Internal feedback, which keeps its loop within the boundary of the system, and external feedback, from which the system receives input from external subsystems as well as regulating the output. The purpose of these processes is to keep the divergence of the variables within the limits of a steady state. One such adjustment process could be organizational learning, which is often recognized as organizational change, through knowledge improvement and exchange of knowledge according to environmental alteration (Argyris, 1999). However, adjustment processes demand time, energy, money, and above all, material and paucity might determine the operation of the system's goals.

The interactions between a regulator, an inspection agent and a regulated organization, were investigated in a separate study. The results from that study are reported in the appendix (ending of this chapter). As with all chapters in this interim report, this appendix was also written as an independent piece of work. This means that some information given in this chapter is repeated in the appendix.

3.1.3 A system approach to safety management

A system approach to safety management is to a large extent evident throughout the international aviation industry. Yet, some problems remain in managing safety as the environment and threats are ever changing. The Canadian Civil Aviation Authorities (CCAA) identified organizational issues as the greatest threat to aviation safety, and suggested that actions by the organization are the required exercise, which will make the system even safer. It was therefore concluded that the most efficient way to make the Canadian aviation system even safer would be to adopt a systems approach to safety management.

The United Kingdom Civil Aviation Authority (UKCAA) have likewise taken a system approach and outlines safety management as a "systematic management of the risks associated with flight operations, related ground operations and aircraft engineering or maintenance activities to achieve high levels of safety performance" (Done, 2002).

In one sense it may be possible to view safety management as an integrated part of overall management. Especially in larger complex organizations such as the aviation industry, where safety management becomes a part of all management in that safety concerns are considered in all aspects of management, in setting goals, planning, and measuring performance. An integrated process established throughout the organization. The CCAA emphasizes that a safety management system philosophy requires responsibility and accountability for safety to be retained within the management structure of the organization (Transport Canada, 2001).

As safety becomes part of the overall management, the process of safety management also becomes part of the organizational culture, a widespread concept throughout the organizational literature, with relation to safety management. A concept referred to as 'safety culture' has been defined as an indicator of safe operations, and is a familiar concept within the nuclear industry. INSAG-4 (as cited in Svenson and Salo, 2003, p. 20) defines safety culture as the "...assembly of characteristics and attitudes in organizations and individuals which established that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance". The safety culture is hence an important contributor to safety operations, both in considering individual's and whole organization's attitudes towards safety.

3.1.4 Organization

According to system theory, the organization is seen as a phenomenon that has been created by the needs of society and not as a constituted tool (Rubin and Kim, 1975). Most people in everyday life belong to some kind of organization, be it as an employee or as a participant in some organized recreational activity. Factories, schools, hospitals and public transport are just a few examples of organizations whose products and services are available to society. Although the concept of an organization is one of common knowledge, it is a notion with multifaceted meanings and has been defined variously depending on its context. Parsons (1960, p.56), much of whose research stems from theory in sociology, defines an organization "...as a social system which is organized for the attainment of a particular type of goal; the attainment of that goal is at the same time the performance of a type of function on behalf of a more inclusive system, the society". In the field of organizational psychology, the term 'organization' refers to a complex social system made up of individuals, their facilities and the products yielded (Reder and Reder, 2001). In this last sense, which is admittedly very general, a small corner shop qualifies as an organization, as does a multinational corporation, a political party or a university. Because of the great latitude of reference here, several criteria are usually applied to the definition in order to limit the meaning. Many definitions stipulate that an organization must possess the following characteristics: the co-ordination of the effort of personnel (who must have some set of common goals or purposes), some division of labor within the larger structure, and some degree of integrated functioning, including a hierarchy of authority (Abrahamsson and Andersen, 1996; Argyris, 1999).

Many organizational theories have been put forward since the earliest studies on organization. Fredrich Winslow Taylor in 1911 was one of the first to draw some conclusions from his experience and experimentation in the steel industry. He arrived at some scientific principle that came to be the core material in his "The Principles of Scientific Management" (1911). In this book, he asserted that in the future the "system" should guide the man, not the other way around (as cited in Abrahamsson and Andersen, 1996).

In general, when studying organizations there are two fundamental organizational theories, the rationalistic and the system theoretical ones (Abrahamsson and Andersen, 1996). The rationalistic theory proposes that the activities of an organization are a function of the goals that some individuals or some groups of individuals have set; that is, the goals that the management of the organization set once upon a time. Moreover, the theory states that the people who are to put these goals in action should have opportunities to be able to judge the different possible alternative ways to reach these goals.

In the system theory on the other hand, the goals do not have such an important function (Katz and Kahn, 1978). Instead, they are seen as a variable that is dependent on the other activities of the organization. The organization does not constitute a tool for the top management's goal. The organization is seen as a structure, which corresponds to, and adjusts to various interests' demands and who seeks to maintain a balance through averting these demands against each other (Katz and Kahn, 1978). The system theory also emphasizes the importance of organizational adaptation and adjustment to environmental change. The process of adjusting to various environmental changes has been illustrated as a criterion for organizations to learn. However, profound debates remain as to whether an organization can learn, or if it is the individual member of the organization that learns.

3.1.5 Organizational learning

Organizational learning is an academic field of study that has examined the process of individual and collective learning within and across organizations and has become a central strategic topic according to Hodgkinson and Sparrow (2002). Organizational learning, for which many definitions exist, "is a process that is evidenced by the degree to which individuals acquire chunks of knowledge, develop and spreads this knowledge within the organization, gain acceptance of it, and recognize this knowledge as being potentially useful" according to Huber (1991, p. 89). In other words, it is a feedback system that could essentially be any reaction to the environment that sets a president for future action. Levitt and March (1988, p. 319) stated that organizational learning concerns "encoding of inferences from history into routines that guide current behavior". According to Argyris and Schön (1978) organizational learning entails the detection and correction of error. Further, when "the error detected and corrected permits the organization to carry on its present policies or achieve its present objectives, then that error-detection-and-correction process is single-loop learning" and "double-loop learning occurs when error is detected and corrected in ways that involve the modification of an organizations underlying norms, policies, and objectives" (Argyris and Schön, 1978, p. 3). As the scientific research developed in the field Garvin (1993, p. 80) intertwined the former into his own definition of organizational learning: "the creation, acquisition and transfer of knowledge, and the skilful modification of the organization's behavior to reflect new knowledge and insights. Seeing the world in a new light. Learning from the organizations own experiences and history, and the experiences and best practices of others".

Just as in similar to human learning, organizational learning builds on two fundamental processes. The first process is based on a limited rational calculation through which expectations regarding future consequences are used to choose between available alternatives. The second process emphasizes learning through experience. The members of the organization act and observe the consequences of their actions (March & Olsen, 1976). The latter process is one of rational adjustment in that learning takes place when the organization collaborates with its surroundings (Hodgkinson and Sparrow, 2002).

Research from a technical perspective argues that organizations as entities do not learn, but that individuals as members of the organization do. Wiech and Wastley, for example, argue that the very notion of organizational learning is an oxymoron (Hodgkinson and Sparrow, 2002). On the other hand, research from a Darwinian perspective, whose basis stems from the Darwinian language of evolution, adaptation and natural selection, sees organizational learning as a process in which "whole organizations or their components adapt to changed environments by generating and selectively adapting organizational routines" (Argyris, 1999, p.7-8). Once again, the notion of adaptation is stressed. Adaptation according to De Geus (1988, as cited in Hodgkinson and Sparrow, 2002) is also the only factor that makes an organism survive in a changing environment. Organizational adaptability, therefore, entails regulatory strategies of a dynamic nature, and the reassessment of these strategies based on legal mandates, and constant economic, technological, and political change, is necessary if an organization is to be taught through adaptation (Durbin, Melber and Blom, 2001).

3.1.6 Regulation strategies

Perhaps a common ultimate strategy for safety management is desired. However, different complex systems are based on different and specialized technologies and activities; therefore, the details of a strategy for managing the safety of that activity must be handled in a very individual manner to reach an optimal level of safety. The strategy chosen will not only depend on the technology and the activity, but also on what risk that activity will bring. Even though the total elimination of risks is desired, "no aircraft could fly, no automobile move, and no ship put out to sea if all hazards had to be eliminated first" (Hammar, 1972).

Rasmussen and Svedung (2000) identified three types of accident categories together with the related risk management strategies. The first category was occupational safety, which focused on frequent, but small-scale accidents. The hazard sources in this category are very complex and the control of safety is focused on the removal of causalities, which is based on empirical epidemiological studies of past accidents. The second category, referred to as protection against medium size, focused on the identification of infrequent accidents, such as aircraft accident. The development of safer systems in this category depends on responses to analysis of the individual, latest major accident. In addition, management is focused evolutionary safety control that is, the removal of causes of particular accidents (Rasmussen and Svedung, 2000). Though the hazards are well defined in these systems, the accident rate in a nuclear power plant, for example, would be so low that, the safety management design could not be based on empirical evidence from accidents research (for example, protection against rare, large-scale accidents). Instead it is based on defenses identified by predictive analysis such as probabilistic safety analysis, PSA.

The organization can choose to implement different regulatory strategies depending on the accident category relevant to the specific activity. Durbin, Melber and Blom (2001) outlined six regulatory strategies that are currently being used in the nuclear power industry, where the regulators must assure safety in the face of significant challenges, similar to the aviation industry. The six different strategies that are based on those developed by the authors of the Swedish Nuclear Power Inspectorate (SKI), were identified as the following; prescriptive, case-based, outcome-based, risk-based, process- or system-based and licensee self-assessment.

3.1.7 The present study, aim and outline

The general purpose of the present study was to describe safety management in a context relevant to the aviation industry by using a framework in which theoretical general systems are essential. The present study will discuss a case study of the Swedish Civil Aviation Safety Authority-SCASA (Luftfartsinspektionen), in which a description of the SCASA's role as regulator of the aviation industry will be outlined. To delimit the scope of the present study, with regard to the multifaceted notion of safety management, the present study will focus in particular on safety management in three perspectives; (1) the structure of the organization, in which a general description of systems will be outlined; (2) Internal as well as external threats against the SCASA and against the market; and, (3) information feedback systems, in which internal and external system feedback will be presented, and incident/accident reports and regulatory strategies outlined.

3.2 The Empirical Study

3.2.1 Method

3.2.1.1 Document analysis

In the present study, documents put forward by the aviation industry have been used and analyzed. Mainly four documents have been exploited, (1) the Business Activity Plan (Verksamhetsplanen) 2003-2006, which has given an overview of and insight in to the SCASA's present and future focal areas; (2) a sectors account for the development of the aviation in 2001, which provided a general knowledge across the industry; (3) an analysis report of all occurrence reports in 1999 that have been analysed by the SCASA; and (4) the Accident Prevention Manual developed by the International Civil Aviation Organization in 1984, which outlines concepts, methods, applications and ideas in relation to preventative safety efforts.

3.3.1.2 Interviews

Participants - Four employees, all men in middle management positions at the SCASA, participated in the study and were interviewed. The participants represented four of the five different sections of the organization: two represented Surveillance located in Sollentuna, Sweden, one represented Regulations (also Operational Approvals), located in Norrköping, Sweden, and the last represented Technical Approvals, also located in Norrköping.

Material - A semi-structured questionnaire was developed and used for the qualitative interviews (see Appendix). Based on the safety management prospective put forward by Svenson and Salo (2003) the questionnaire covered three approaches to safety management. First, the structure of the organization, which concerns the identification of main, statistical, and perceived risks; the organization's definition of safety management; as well we the structures and processes relating to safety management. The second approach concerns threats against the organization and finally and the third approach covers information system feedback. This entailed the examination of internal feedback (ex: incident and accident reports), external feedback (i.e., the relationship between the SCASA and the market), and finally, of regulatory strategies.

Procedure - A letter was sent to a contact person at the SCASA in order to establish initial contact. This letter defined the essence of the study, and questioned whether employees were willing to be interviewed. An acceptance was later received and the contact person suggested five different employees who were willing to be interviewed. The author later contacted these individuals either by e-mail or by telephone to specifically ask if they were interested and to arrange dates for the interviews. Four of these five individuals confirmed their willingness and interview dates were finalized. The fifth was at that time on vacation and suggested a date three weeks after initial contact was established. This entailed that that the interview would have taken place outside the time span available and therefore he did not participate in the study.

A letter of information was then, also given to the participants at the interview occasion, again to clarify the essence of the study (see Appendix). The interviews were held at four different occasions during which the participants responded to a set of questions in the semi-structured questionnaire, which had a time span of about an hour and a half. The author asked the questions while a research assistant recorded the responses. Following the interviews, the responses were summarized and sent to each of the participants, enabling them to add information and/or correct the material.

3.2.2 Results

The results will firstly be provided in a general description of past as well as present characteristics of the air transportation industry, followed by a brief outline of the SCASA as a regulatory organization, with general proceedings, visions and goals, all based on the document analysis. Finally, based on the interviews the results will be presented in accordance to the three approaches taken to safety management in the semi-structured questionnaire.

3.2.2.1 The Air Transportation Industry

In its infancy, aviation was merely a vision of humans imitating the soaring patterns of birds. From that vision, Leonardo da Vinci´s pioneering work in the 1400's, on the possibilities of flying developed and laid the foundation for the scientific study of aviation. However, it was not until December 17th 1903 in Kitty Hawk, North Carolina, that American brothers Wilbur and Orville Wright carried through the first test of flying, today considered to be the first successful attempt to fly (Anderson, 1997).

Until World War I, aviation was the domain of the individual and no organized system existed for the exchange of safety information. The War changed this by providing a stimulus for the creation of large-scale aircraft industries. Ever since then, the civil aviation industry has been growing at a rapid rate. Ongoing technological advancement, considerable international network with safety organizations, huge financial budgeting and a development of services have collectively come to define the network of the aviation industry (International Civil Aviation Organization, 1984).

Favorable conditions of the past, when aviation was a blooming business, the present dynamic society brings with it some dramatic changes of the conditions of aviation management and safety. The attacks on New York and Washington September 11, 2001 are still affecting the market and the aviation industry has never faced such financial hardship. More than 250 000 employees around the world have been affected by the downsizing of the airline companies. In addition, the overall travel demand has decreased by 10 percent and the losses for the aviation industry during 2001 have been estimated between 130 and 150 million SEK (Luftfarstverket, 2001).

The world around us continues to face hardship. Not only are the terrorist attacks still affecting the aviation industry, the current situation in Iraq presets new threats to the industry. While the actual danger of flying has not increased, an almost world wide fear have developed because the terrorist attacks. According to J. Söderström (personal communication, June 10, 2003), the reservation statistics for the Commercial Airline Companies fell 50 percent on the very first day of the war. Thought, the reservations are recovering with about the half, weeks after it is still a huge loss for the industry. Despite the turbulence and the reduction of travelers it is not statistically dangerous to fly with large passenger aircrafts. In 1994, 1385 people were killed in 47 accidents around the world during flights. The average in a 10-year period is 720 per year (Brandsjö, 1996). Comparing this with numbers of people killed in traffic, which is estimated to 82.649 in year 2000 (International Road Traffic and Accident Data, 2003).

Terrorist attacks are not the only threat to the aviation industry. Additionally to the situation around the world that constitutes threat to the aviation industry the aviation market has during the last twenty years been characterized by large turbulence and an increase in merging airline companies. This has lead to downsizing processes and outsourcing parts of the organization and recently, to the development of low budget airline companies which have made huge success (Luftfartsverket, 2001)

This development leads to competition among traditional airline companies, and in trying to remain successful, these companies put themselves at risk. In order to keep prices down, resources and personnel must be cut. These changes can often render a company temporarily unstable, and in these circumstances the SCASA must take particularly care to ensure that safety concerns are not compromised- that safety regulations and demands are kept in a stable state.

3.2.2.2 The Swedish Civil Aviation Safety Authority; The regulatory activity

The SCASA serves as the regulatory authority of the Swedish air transportation. They have a difficult and complex role in limiting the occurrence of incidents and accidents. The investigation of incidents, often instigated by a combination of interrelated factors, is a process of discovery, monitoring and sanctioning- a process inevitably constrained by the relation between regulators and regulated (Reason, 1997).

SCAA shall, according to the regulation (1988:78) with instructions for SCAA, "practice inspection over the safety for the commercial aviation". The SCASA as an administrative part of SCAA then carries out these inspections, though with aviation safety issues being an independent division within the SCAA. With words like openness, consequence, objectivity, competition neutrality and quality, the SCASA shall encourage a positive co-operative atmosphere towards the market. (Luftfartsinspektionen, 2003). They envision their safety work within the Swedish aviation industry serving as a model for the rest of the world. The Swedish rules related to the safety of the aircrafts are of a higher standard than the rest of the worlds, nevertheless, Sweden have to accept the some what loser rules related to other nationalities which is to enter the airport.

Fundamental to the SCASA is the Swedish Aviation Law and the Aviation Order that reflects the guidelines developed by the ICAO that explain how the authorities intend to carry out their statutory mandate. Also fundamental, is the European regulations and directives through the Joint Aviation Requirement (JAR) pertain as a result of the Swedish membership of the European Union and the European Aviation Safety Agency (EASA). Additionally, the section for regulations together with these international bodies develops local regulations, Regulations for Civil Aviation (BCL), (see figure 3.2.). These international bodies further control the overall course of action throughout the organization.

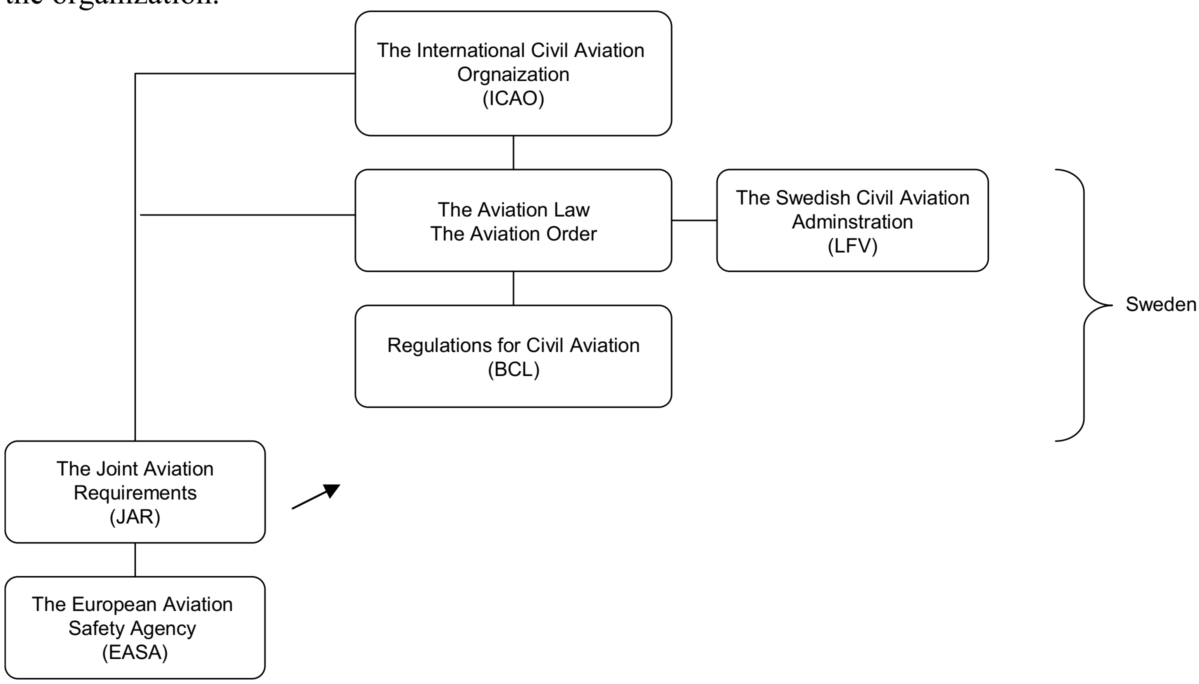


Figure 3.2: Graphical representation displaying the Swedish Civil Aviation Safety Authority's general proceedings within the organization.

The SCASA's safety strategy and concrete goal stipulates that: (1) the aviation safety standards in Sweden shall be in accordance with other well developed nations; (2) number of accidents per fly-hour and year should been halved during the period 1998-2007; and (3) the protection against criminal actions within civil aviation shall be in accordance with other well developed nations.

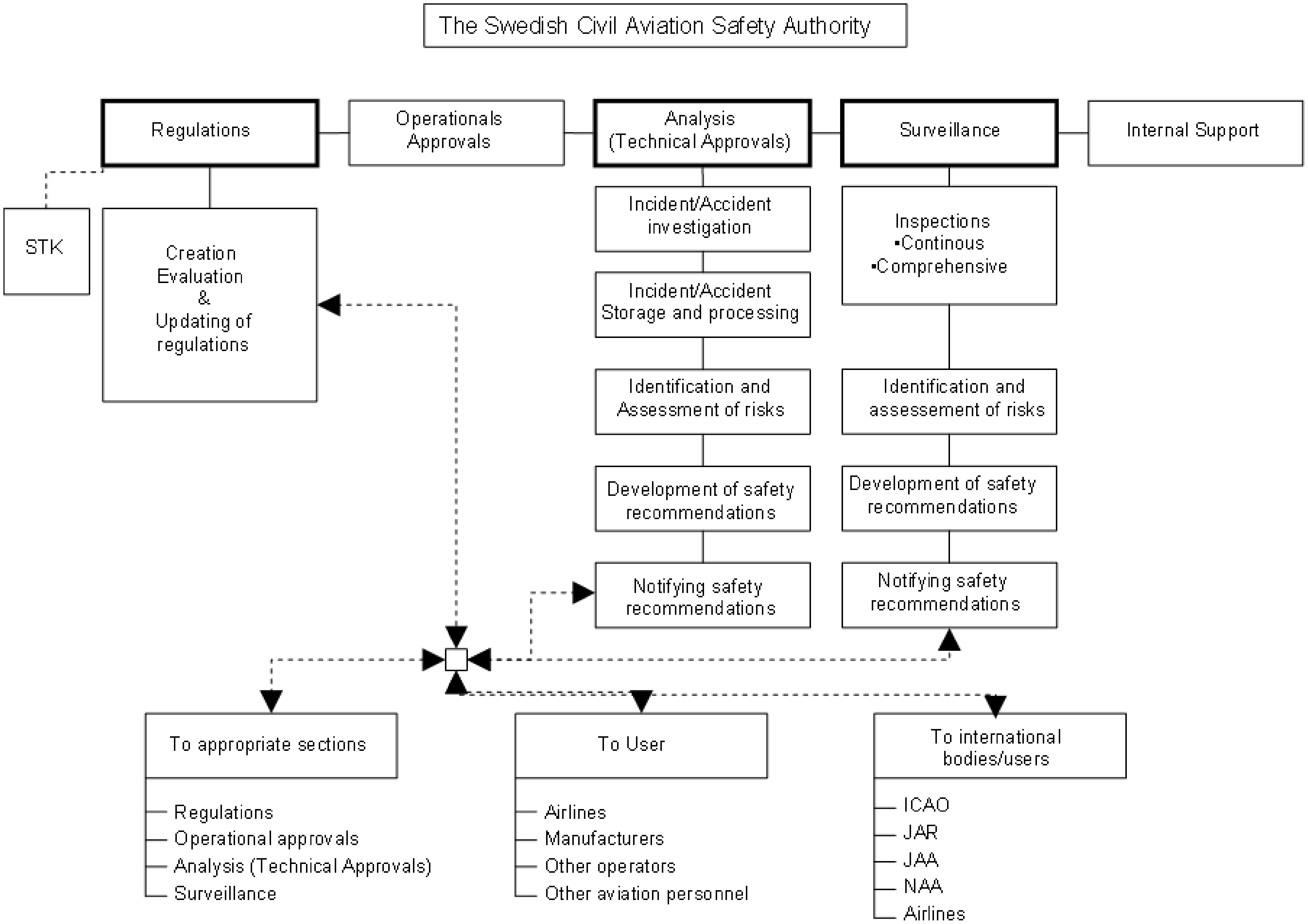
The SCASA has chosen five perspectives, which currently emphasizes their most important areas of focus. The perspectives are: (1) the customer, the aim to create a confiding relationship between the regulated activity and the regulator, (2) the co-workers, this perspective should safeguard and develop the regulator's members knowledge and competence, (3) production, what services and products should be accomplished, (4) economy, opposing how to create the resources that are required and how to full fill the duty as regulator within the financial frame given and (4) internal work methodology, this final perspective outlines how the regulator should work, how they are to create the services demanded by the customers and how they can improve their activity (Luftfartsinspektionen, 2003).

3.2.2.3 The structure of the Swedish Civil Aviation Safety Authority

The overall observation was that the SCASA as a regulator emphasised a systems approach characterised by a clear structure, commitment and strategies. The directors and middle management are ultimately responsible for safety, as they are responsible for other aspects of the enterprise. This is the logic that underlies recent regulatory initiatives.

The SCASA constitutes five sections, each featuring offices with specialized subject areas. The sections are Operational Approvals, Technical Approvals, Surveillance, Regulations and Internal Support. All sections are located in Norrköping, Sweden, except for Surveillance, which is located in Sollentuna, Stockholm. This structure of the organization is a result of their reorganization, which was finished and implemented in June 2001. A structural representation of the SCASA from a selected safety perspective can be seen in figure3.3.

Figure 3.3: Structural representation of the SCASA from a selected safety perspective.



The Swedish Civil Aviation Safety Authority
Regulations
Operationals Approvals
Analysis (Technical Approvals)
Surveillance
Internal Support
STK
Creation Evaluation & Updating of regulations
Incident/Accident investigation
Incident/Accident Storage and processing
Identification and Assessment of risks
Development of safety recommendations
Notifying safety recommendations
Inspections
•Continous
•Comprehensive
Identification and assessement of risks
Development of safety recommendations
Notifying safety recommendations
To appropriate sections
Regulations
Operational approvals
Analysis (Technical Approvals)
Surveillance
To User
Airlines
Manufacturers
Other operators
Other aviation personnel
To international bodies/users
ICAO
JAR
JAA
NAA
Airlines

3.2.2.4 The reorganization of the Swedish Aviation Safety Authority

In June 2001, the SCASA was reorganized for the purpose of developing more practical and efficient responsibility areas. As a result of this reorganization, the structure is clearer, and people (both affiliated and non-affiliated with the organization) know to whom they can express questions and concerns. Nevertheless, the reorganization is still new and is not yet stabilized so it can be hard to comment on the future development of the organization.

The implementation of the new organization demands endurance, as well as a continuous inclination toward innovation. The organization has now edified new leadership with a new alignment and increased delegation. The latter demands an increased involvement for all members of the organization and the delegation assumes that the processes are implemented and in use. However, if some members do not implement the new structure, this could threaten the SCASA as was suggested by one interviewee. Because implementation processes have to be evaluated and then perhaps adjusted and reimplemented a lot of effort and energy are often taken away from the main tasks of duty.

According to the majority of people interviewed, allocating time and effort to the reorganization did not affect work where safety was concerned. It was estimated by 3 of the 4 interviewees that between 40 and 60 percent of their time were devoted to the reorganization during the estimated year it took to complete. And according to these 3 participants, this has lead to an increased prioritizing of work, which always has to be done. This prioritizing can result in the small things growing into bigger proportions. For example, the inspections of the airlines' systems that are used to check whether the pilots can do their work, whether they are updated and follow the rules and so forth, have not been inspected for some time. The interviewee suggested this could lead to a lax attitude, "no one ever checks why bother!", even though it is not a current threat. This was, however, not considered by any of the participants as a threat to the SCASA.

It is also considered by one of the participants that communication has been better since the reorganization as they work closer to each other. As well as a better communication, improved accessibility to their chief leaders has developed a change in leadership has also developed. Increased delegation of the staff has resulted in a much more independent work situation. Despite the assertion of improved communication it is believed that increased discussion regarding safety policy is needed. Of course, it being of a high safety level already but what do they mean by it, how are these policies to be interpreted. This is an ongoing issue within the organization.

Prior to the reorganization as well as after the implementation of the reorganization, the SCASA faced a period of continuous resignations, which has resulted in a process by which competence needs to be established to make sure it corresponds to new demands as the industry becomes more and more complex and turbulent. The salaries created by the market and the localization of the SCASA, in Norrköping, makes the SCASA as an unattractive employer. However, when the organization has periods when the workload is increasing remarkably, retired employees return for a period of time to help out.

The reorganization was a risky prospect in that it was possible that not everyone would accept it. If some people felt left behind in the old structure, a situation could develop in which people did not consider themselves part of the organization, and subsequently work upon their own beliefs. To avoid such a situation, the structure has to be implemented in a good way. However, responses are bound to be influenced by the sections in which the participants were operating, and the extent to which those sections were affected by the reorganization.

3.2.3 Threats to safety

It is important to notice that these threats, statistical and perceived threats to the SCASA, may indirectly serve as a threat to the market, at the same time as threats to the market may constitute a threat to the SCASA. The necessary close interaction between the systems creates a difficulty in separating these from each other.

3.2.3.1 Internal threats to the Swedish Civil Aviation Safety Authority

Numerous of internal factors may erode the safety of an activity. One such factor that was identified by 3 of the 4 interviewed was the process of creating, evaluating and updating regulation. It was regarded that the SCASA constantly found them selves in a position of being behind. The regulations are too few and they do not match the currently fast development in technology. However, the process of regulation writing is a constant one and a complete rule can take up to four years to write and implement. It also creates a hard situation because of the very rapid technological development and difficulty in progress in changes while maintaining the same routines as is characterized in the general of aviation. In addition, one of the interviewed stated that there had not been a single new rule written since the reorganization was implemented. Thus, there is a gap between the rules and the current reality and closing this gap is one of the SCASA's goals.

Another major internal factor, which may erode safety that was also outlined by 3 of the 4, interviewed, was the inspection area. In general there are too few inspections and too few inspectors. The systems approach to SCASA´s inspection philosophy has made it possible to carry out the inspection tasks in regard to its recourses allocated in the expanded and more complex aviation industry. Yet, the ICAO, who along with the JAR has expressed demands on increasing frequencies of inspections, has criticized this approach. This was also noticed by the ICAO who identified 28 remarks in Sweden concerning the area of inspection, considering them having to few inspections and inspectors. On the other hand, it was also stated by interviewees that there were no problems regarding the inspection when recourses were considered.

One reason for this might be the difficulties of recruiting personnel, which was a third general internal factor identified especially by one of the participants, which may erode safety. Competence is hard to find within the area, as the requirements demand years of experience and knowledge within the aviation field. Three of the four interviewees stated that threats to the expansion and development of personnel's knowledge and experience constituted a potential threat to the organization as a whole. Another reason recruiting is difficult concerns the geographical location, Norrköping being a small town, and salaries not being the most preferable. As one of the unwritten requirements for employment is the experience of being a pilot along with years in the aviation industry, follows that they are used to a wage level that is about three times the salary of a flight inspector. It is hard to justify that choice of working for a government authority, thought it might provide a higher employment security. This situation different to that of in England, in which being a flight inspector is, regarded as very high status and they have considerably higher salaries. An additional internal threat, which was considered by the SCASA, was the danger of an inhibited openness between them and the airlines.

3.2.3.2 External threats to the Swedish Civil Aviation Safety Authority

In addition to internal factors, external factors may erode safety as well.
The major external threat that was agreed upon by the interviewed was the financial situation. One of the interviewed identified the problem as charging to little money for the services and suggested that in doing so it will provide less opportunity for inspections.

Another major threat that was generally agreed upon by the interviewed concerned the competition that the market is facing, with the ever-growing low budget airline companies. In order to maintain the low prices, the market is being pressured to cut down on recourses, which results in having modest margins. This leads to an increased workload at the SCASA, as they have to increase the inspections in response to the limited recourses, which results in even greater proportions of prioritizing from other assignments.

3.2.3.3 Internal threats to the market

It was stated by one of the interviewees that the rules applied by the SCASA are a minimal level that has to be followed in order to maintain the activity which the airline companies runs. Hence, it was not noticed by the SCASA that, which according to Svenson and Salo (2003, p.3) could be an internal threat, being a "slow gradual degradation of safety (organization, people, technology) below a just noticeable difference (JND) between the times of observation". In addition, it was stated that if the SCASA demands too strict regulations, the Swedish market would disappear into the international one.

It was noticed by the SCASA that they saw the danger of having a frivolous management, as they are the ones that create the general atmosphere in the organization, and put a top priority on economy and efficiency before safety. In a situation in which the pilot's relationship to the management is disentangled regarding safety related issues, it may create an internal threat by furthering the risk of the activity. This is according to Svenson and Salo (2003, p.3) another internal factor that may erode the safety of the organization in where "safety goals turn out to be in conflict with other goals and looses in a goal conflict".

3.2.3.4 External threats to the market

As the world around us is changing with a seemingly increased threat from terrorist attacks one would believe that this must have affected the aviation industry greatly. Indeed, where the security division is concerned, there is a constant mission of finding the right balance between the accessibility and the safety of the aviation, though, one can never guarantee it being completely safe. Measures such as checking a hundred percent of the luggage as well as a hundred percent of the passengers are taken.

Again this has also affected the SCASA's inspections, as they have to increase especially when the aviation industry finds itself in a critical position.

3.2.4 System feedback

3.2.4.1 Internal feedback

Regarding to the structural characteristics of the SCASA structure in which the interaction and communication between the sections ought to be bound, a functional internal system feedback is essential. It was noted by one of the interviewed that there is a lot of work being repeated as a result of a defective computer system in which a lack of interaction between the sections are present. One of the interviewed also pointed out that too much information was circling around, rendering it impossible to read and relate to. He further asserted that the information ought to be more specific and related to the employees subject areas.

The information flow between the sections, especially between Surveillance, located in Sollentuna, and the remaining sections in Norrköping, was regarded by two of the interviewed as problematic. One stated, "it is always hard for the management to lead with distance, it being more practical if they were located here in Norrköping with the rest of the authority". Whereas another, who is stationed at Sollentuna, stated "I think the communication have improved between the sections".

3.2.4.2 Means of communication

In general, formal meetings and electronic mail were the main means of communication. Managerial body meetings were held every second week, while section and office meetings were held every week. One participant felt that the meetings were too frequent, and contributed too much information circling around, the same person regarded the meetings as sometimes too much.

Along with formal meetings, informal meetings such as coffee breaks were also viewed by the majority as being especially important. Casual conferences in the corridor were being estimated to take place three to five times a day. These diminutive conferences were regarded as extremely important to promote information flow, maintenance and increase of competence, as well as the endorsement of a pleasant and social work environment. The reorganization has contributed to improved communication, by placing members of the SCASA closer to one another. The issue of interpreting of certain safety matters is a constant process as rules and policies are always going to be a matter of interpretation, which is going to differ from person to person. It was commonly held that the informal meetings were also regarded important from this point of view, and that it was easier interpret matters collectively.

The SCASA employees have years of experience in the aviation industry, most of them being former active pilots. Subsequently, numerous contacts have been tied together through out the years and informal contacts have come to constitute a large proportion of the means of communication within the SCASA.

3.2.4.3 External feedback

It was reported that these informal means of communication were also a very important means of external communication between the regulator, SCAA and the airlines. One of the participants working at Surveillance commented on his almost daily contact with the airline company, it being the customer of his.
The communication and feedback between the SCASA and SCAA was merely explained as something that is executed on a higher managerial level.

3.2.5 Incident and accident reports

In the Accident Prevention Manual published by ICAO (1984, p.38) it is stated "incident and accident report should not be regarded as a means to an end in themselves but rather as the first of several steps towards accidents prevention". Instead it should be regarded as a feedback system in which a series of one type of incident/accident may indicate a weakness in a special area. Incidents and accidents are a plentiful source of risk information and lessons learned from the investigations of these ought to be incorporated and part of that feedback system.

Incident reports are written by the airline company and then submitted to the SCASA for analysis, which entails classifying the given incident according to different types of occurrences, that is, operational, technical or environmental. A disadvantage of the present category system of occurrence reports is that a system for classifying potential risk for each occurrence, so-called, 'Risk Assessment', has not yet been set (Luftfartsverket, 1999).

Following the classification, recommended measures and a priority list of the risks involved are determined. This ought to entail that the SCASA would recommend measures on the top priority risks. However, the way in which the SCASA is working, which is based on prioritizing and due to the optimization of resources allocated that are based on facts, it signifies that the measures recommended are being weighed against different considerations such as financial and political which entail it not always being the most safe alternative that is being recommended. However, the SCASA states that this is always a balance that has to be maintained in order to keep the organization in a steady state.

In 2002, a total of 2482 reports, concerning all 7 activity areas such as Heavy Jet planes, Light Jet planes, Helicopter and Civil Aviation, were submitted to the SCASA. 2272 of those were identified as disturbances without any damages, 89 were incidents and accidents where damage could have occurred and 121 of them were technical reports (Hummerdal, 2003). During 1997 and 1998, 450 reports concerning only Civil Aviation were analyzed by the SCASA. These reports indicated that the highest frequency of occurrence was "flying without permission". In a report from the Scandinavian Civil Aviation Supervisory Agency (STK), it was stated that overall, more than a hundred departures within the SAS airline occurred with aircrafts that had not fulfilled the demands of airworthiness (S, Christianson, personal communication, May 28, 2003).

The number of reports has steadily increased during the last years. One should not interpret this increase of reports as a symptom of the deterioration of airline safety, but rather as an indication of honesty and a willingness to admit to error, qualities that reflect a good safety culture.

The aviation industry uses The Aviation Safety Reporting System (ASRS), developed by NASA, which provides a great example of a system that features an open and trustful information subsystem. This information system is characterized by a willingness to report an incident/accident and this tendency towards honesty is evident and remarkably high in comparison to several other countries (Luftfartsverket, 1999).

In May 1994, the government decided that all Swedish authorities should execute risk analysis on a regular basis in order to compute the financial costs of the risk management, limit risks, and prevent incidents and accidents from occurring. The Swedish National Audit Office (Riksrevisionsverket) found that nearly fifty percent of the Swedish authorities could have defective knowledge regarding risks, damages and incidents in the activity. In addition, twenty-five precent state that regular risk analysis has not been carried through on a regular basis (Riksrevisionsverket, 2003).

3.2.5.1 Measurement of safety

It is highly desirable to monitor the effectiveness of incident/accident prevention efforts as well as the recommendations issued by the SCASA.

3.2.5.2 The Swedish Civil Aviation Safety Authority's measures

There are three ways in which the SCASA measures their strategic goals as they relate to safety of their production: one is number of regulations issued, another is number of inspections and deviations, and the last is number of occurrence reports and accidents (Luftfartsinspektionen, 2003).

3.2.5.3 The market's measures

There is basically two ways that the market can measure the safety. One refers to number of accidents, incidents and fatalities, etc. and the other implies accidents rates. The latter being the only source from which, valid comparisons can be drawn. For example, if two types of aircrafts are compared and type A has one million flight hours in one year resulting in one accident, and type B has five million flight hours in one year resulting in seven accidents, the former type of aircraft indicates an accident rate based on flight hours being statistically preferable (International Civil Aviation Organization, 1984).

3.2.6 Regulatory strategies

The regulatory strategies applied and coined in the nuclear power industry could be related to the aviation industry. There are two strategies applied by the SCASA. The first could be described as partly prescriptive; a strategy that provides very detailed requirements that the airlines must follow in conducting their activity. The second is partly based on self-assessments; a strategy which requires the airlines to develop and implement a self-assessment program to identify both good practices and problem areas needing improvement, which the regulator evaluates (Durbin & Melber, 2002).

In a complex system with multiple interactions between the suprasystem and the subsystems as in the aviation industry, the accident category cannot act as the only predictor of chosen regulatory strategy. Other factors such as the characteristics of safety issues, the nature of the relationship between the regulators and the regulated, the public and, political and legal bodies will influence on the choice.

3.3 Discussion

The present study has given a narrative of safety management in the Swedish Civil Aviation Safety Authority (Luftfartsinspektionen, SCASA) in which a system approach was essential. The structure of the organization has been illustrated in a structural representation selected from a safety perspective and threats against the regulatory activity identified. Insufficient inspections and incomplete regulations that is in constant need of evaluation and creation, was identified as being the main threats against the SCASA, which may have effect on safety. Financial hardship, and a management marked by unbecoming levity in which safety goals conflict with other goals such as profit and efficiency were identified as being the main threats against the market. Finally, the information system feedback of the SCASA was described. As well as above issues, limitations of the study and methodological issues will be discussed and future research outlined.

3.3.1 The Swedish Civil Aviation Safety Authority, the regulator

The SCASA's general safety strategy and concrete goals stipulated that aviation safety standards in Sweden shall be in accordance with those of other well developed nations and that number of accidents per fly-hour and year should have been halved during the period from 1998-2007. Despite these strategies and goals, the five perspectives that the SCASA currently considers the most important areas of focus do not mention safety. One explanation for this might be that the areas of focus are considered to be related to the SCASA's 'pure' business plan in their work towards their customers. One may argue though, that if the systems approach is to permeate all levels of the organization, safety should defiantly constitute a part of all processes.

3.3.2 The structure of the SCASA

The structure of the SCASA, as put forward in figure 1, reflects the processes of the organization as structures and processes within SCASA seem to be well accommodated to each other. However, there are differing opinions regarding the legibility of the structure at present. Due to the recent implementation of the reorganization it is difficult to lay down whether this is just a matter of getting used to the implementation or if it really was better before the reorganization even though one of the main purposes for the reorganization was to get a more legible structure. Another reason for this might be that the different sections were affected disparate by the reorganization. Some sections were completely reorganized through downsizing its unit from 24 members to 4, which would be a rather great alteration while other sections were not affected at all.

It was noticed by some of the interviewed that one major disadvantage of the structure is the present location of the surveillance section, Sollentuna, located 2 hours from the head office in Norrköping. This could create communication problems and distant management may always be difficult. This was also noticed by some of the interviewed.

Though the distance is large between the surveillance section and the rest of the organization, the present location of the members working in SCASA in Norrköping have been improved, and managers are easier to get in contact with. This is a major advantage of the structure, as communication will thrive if, simply, it is easy to communicate. Communication is likewise most important in controlling those threats against the SCASA and the market, which may erode safety.

3.3.3 Threats to safety

The complex industry of aviation brings with it numerous of factors which may erode safety. The insufficient inspections and incomplete regulations identified as the major threats to the SCASA by the majority of the participants, constitutes an issue of concern. These threats in the end may be the fundamental part of the substance of threats to the market and further to the individual when flying.

If the airlines are to have a good safety record, SCASA must provide great work in following up the incidents and provide great recommendations. In order to provide such work, extensive inspection criteria have to be meet. According to SCASA, they had enough staff and all posts were filled, they still emphasized that with the present workload it is always a matter of prioritizing, as they did not have time for every single case. Is it then really the case that the SCASA is not in need for further resources? Probably, but as it is decided by the management that no more positions should be either created nor filled, the financial situation is probably not allowing it. An organization that is never in need of further resources and always has the time for every single task would probably be a dream scenario- a perfect organization, but does it exist? Nevertheless, it is important to strive for one and to emphasize those little things that the staff does not have time for, as they could be those little things that build up and could constitute that little last bit in the chain of defence of a potential accident.

The present situation seems to be characterized by an increasing workload during certain periods. This increase results in demands for further analysis by the inspections and regulations, which in turn takes prioritizing even further, and it is the demands for further resources, which completes the vicious circle. One explanation of limited resources could be to the reorganization and the great effort and energy it often requires. On the other hand, this seems to have been a problem even before the implementation of the reorganization as the Surveillance section was not to a greater extent affected.

3.3.4 Information system feedback

The information system feedback, which, according to some of the participants was lacking seemed yet to be an example of a communication system that works, but will always be in need for improvements.

One factor, which may indicate good communication, is the increasing number of reports reviewed by SCASA. An organization with a good safety record, meaning few rapports, is not necessarily a safe organization, for one could, argue that the more rapports the organization is handling the safer the market could be considered. Evident from the increasing number of reports over the last years, SCASA seems to have installed in the market a willingness to report on incidents and accidents. Due to the very notion of the SCASA as a regulator, in motivating appropriate behavior of the market and avoid de-motivation of appropriate behaviors. They somewhat seem to have succeeded.

Another factor which, at first hand may indicate a favorable means of communication, is the informal contact between the employees throughout the industry.

As most of the employees at the aviation authorities have been former active pilots with years of experience in the aviation industry, they tend to become friends. While this may first seems to be the making of a healthy work atmosphere, which it also can be, one may argue, however, that this is correspondingly set for use of insidious purposes.

The case study illustrated, to the best of the authors' knowledge, high quality safety management. A management process that evidently considered a systems approach which is essential in such complex socio-technical systems such as in aviation. International aviation has taken this approach for some time, as they are aware of the disastrous effects an accident could have. A potential accident in these industries would not only affect the individual but also the subordinate society; therefore, the importance of dynamic interaction among subsystems and suprasystems is essential.

The nature of the risks and the environment will constantly change and so one must remain alert for the changes and take preventative actions. The flexibility of the industry is thus essential, as successful safety management is largely dependent on the industries ability to adapt to a constantly changing environment.

Ultimately, SCASA gives a general impression of being in good relation to its regulated organizations with a clear regulating structure. However, SCASA will have to arrive at an understanding of how its regulatory strategies can and will affect the safety of the regulated, both positively and negatively. Recognition of the SCASA's vision is an endeavor for the future. With improvements of a general system approach they may in time serve as a model for other developed nations and provide an even safer aviation for all.

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3.5 Appendix

On the interactions between a regulator, an inspection agent and a regulated organization.

I. On the interactions between a regulator, an inspection agent and a regulated organization.

This appendix is focused on the interactions between the actors in the air transportation field. To make the text a stand-alone document it also includes short presentations of organizations that can also be found in the main text.

Introduction

The aviation industry is a complex set of organizations resting on a foundation of laws and regulations closely monitoring all parts of the industry. Despite a continuous growth in air transport demand that increases the pressure on the system, air accidents are extremely infrequent in the perspective of the quantity and the intensity of the operations and activities involved in civil aviation. Activities as complex as operated in processes geographically dispersed and regulated by different international and national safety bodies need to be managed in a systematic manner.

The present paper will describe some parts of the interactions between (1) the regulated organization, the Scandinavian Airline System (SAS) and its regulator, (2) the Swedish Civil Aviation Safety Authority (Luftfartsinspektionen, SCASA) and (3) the Joint Scandinavian Safety Inspection Office (Skandinaviske Tilsynkontor, STK) which is the inspection agency for SAS only. The intention is not to present a complete description of the three organizations, and their interactions but rather illustrate relevant structural relationships among the three entities which may be important from a perspective on safety management. In systems terms the present paper is focused on the feedback to the civil aviation industry (exemplified by SAS) from societal systems and from the particular inspection organization for SAS only.

Method

Document analyses

The following documents have been used and analyzed: (a) Accident Prevention Manual- International Civil Aviation Organization, ICAO, (b) the Business Activity Plan (Verksamhetsplanen) 2003-2006 for SCASA, (c) The SAS group Annual Report 2002. Documents from STK were not available for public use. An excerpt from the Quality Manual 2003 was however provided.

Interviews

Two visits to corporate headquarters of SAS during which two informative interviews took place with three employees working under the Scandinavian Operations Management unit. An additional interview was conducted at STK with an employee in a leading management position.

Aviation regulation

Regulation of the use of civil aviation in Scandinavia (and internationally) is based on the International Civil Aviation Organization's (ICAO) recommendations: An organization with a regulatory-related role, which "is to provide guidance and procedures for the safe conduct of international aircraft operations and to foster the planning and development of air transport" (ICAO, 1984, p. 7). This is mainly achieved by developing standards and recommended practices, which are enclosed in the Annexes to the Chicago Convention, which was signed in 1944 by a total of 32 states. The standards and recommendations are thus fundamental for the national aviation law and the aviation order but not legally binding for the member states.

In addition to ICAO's recommendations, European orders and directives pertain through Sweden and Denmark's membership in the European Union. On September 28, 2003 the European Aviation Safety Agency came into being, an agency of the European Union, which has been given specific regulatory tasks in the field of aviation safety (EASA, 2003). However, regulations, rules and instructions in themselves do not prevent accidents and unless they are enforced they are of little value.

SCASA – The Swedish Civil Aviation Safety Authority

The enforcement of these regulation, rules and instructions is one of the SCASA main assignments. The SCASA serves as the regulatory authority of Swedish air transportation as described in the main part of this chapter. The Swedish Civil Aviation Administration-SCAA (Luftfartsverket-LFV) shall, according to the regulation (1988:78) with instructions for SCAA, "practise inspection over the safety for the commercial aviation" (Luftfartsinspektioen, 2003). The SCASA as an administrative part of SCAA then carries out these inspections. The SCASA's inspectorial work is financed partial through fees (about 60%) taken from the airlines and partly depended on financial contributions (about 40%) from SCAA.

The SCASA's safety strategy and concrete goal stipulates that: (1) the aviation safety standards in Sweden shall be in accordance with other well developed nations; (2) the number of accidents per flying-hour and year should be halved during the period 1998-2007; and (3) the protection against criminal actions within civil aviation shall be in accordance with other well developed nations. To implement these goals in actions SCASA has chosen five perspectives, which currently emphasize their most important areas of focus. The perspectives are: (1) the customer, the aim to create a confiding relationship between the regulated activity and the regulator, (2) the co-workers, this perspective should safeguard and develop the regulator's members knowledge and competence, (3) production, what services and products should be accomplished, (4) economy, opposing how to create the recourses that are required and how to fulfill the duty as regulator within the financial frame given and (5) internal work methodology, this final perspective outlines how the regulator should work, how they are to create the services demanded by the customers and how they can improve their activity (Luftfartsinspektionen, 2003). In the main text, the reader may find some critical comments regarding SCASA.

SAS- Scandinavian Airlines System

One of the largest airlines that are regulated by the SCASA is SAS. The overall structure of the SAS group, in the beginning of 2004, was organized in five business areas: 1) Scandinavian Airlines, which is given the focus in the present paper and will be referred to as SAS throughout the paper, 2) Subsidiary & Affiliated Airlines, 3) Airline Support Business, 4) Airline Related Business and 5) Hotels. Each area is sequentially organized in different sections (SAS, 2002). The legal structure of SAS is Nordic (14,3 % of the shareholders represent the Danish State, 14,3% the Norwegian State, 21,4% the Swedish State and 50% private interests) and therefore decision-making procedures, regulations and policies are complex.

The structure until early 2004 of SAS rested on the foundation of the Scandinavian corporation between the Danish (DDL), the Swedish (SILA) and Norwegian (DNL) parent companies set in 1946 to form Scandinavian Airline System (SAS). The SAS was the fourth-largest airline group in Europe (SAS, 2002). Today, however, the SAS group and the whole industry are facing a formidable challenge to position the airline in a market portrayed by an economy that has never been weaker and an increasing competition, despite the rising air transportation demand. With annual operating revenue of 37,163 MSEK, 22,1 million passenger/year, 810 daily departures to 86 destinations and 7,556 employees, the income after tax, was yet, for 2002 negative. In spite of this, extensive financial and organizational recourses are allocated to safety management. An articulated safety management structure, safety objectives and decision-making procedures and audit and inspection systems has emerged as a result of the great emphasis on safety. SAS keeps abreast with the governmental standards for safety but it also adopts internal standards that are stricter than the rules and regulations set by the safety authorities. However, the existence of integral rules that are stricter than those required by society may lead to uncertainties. For example, according to a pilot interview, the crews are uncertain about the safety margins in relation to societal regulation of the SAS rules. Therefore, in particularity demanding situation the SAS crews do not know how far they can stretch the SAS rules and yet act within legal limits.

STK- Skandinaviske Tilsynskontor.

The inspections of the SAS-companies are executed through the STK. The ultimate quality objective of STK is to "contribute to the achievement and maintenance of the required flight safety levels in the assigned organizations" (STK, 2003). According to STK's quality policy, STK "shall exercise [our] their obligations in a systematic way, and [our] their actions shall be predictable and in accordance with governing rules and regulations" (excerpt from Quality Manual, 2003). STK is administratively subordinate to OPS-utvalget, which is the Scandinavian coordination body for aviation safety in Sweden, Norway and Denmark. OPS-utvalget is composed of the directors of the SCAA, Norway and Denmark that is the decision-making organ. The administrative part of OPS-utvalget is STK, which executes the surveillance. STK which only assigned organization is SAS, has three inspection objects within the SAS group, namely the SAS Airline, SAS Commuter and SAS Flight Academy. The organization has one unit responsible for Technical Surveillance and Technical Audits, one unit for Flight Operations Surveillance including SAS Commuter and one unit for Flight Simulator Surveillance. Currently there are 14 employees in the STK. In addition to this the Scandinavian Flight simulator Group, has members from the three Civil Aviation Authorities. Despite that aviation being a very close monitored activity, the airline has the full responsibility for carrying out their operations in accordance with the rules and regulations set by the regulator.

STK shall according to regulations work cover the paragraphs and provide necessary adjustments governing the surveillance work in a two years period. The surveillance activities are classified into audits or inspections. The former includes surveillance on whole systems where as the latter includes surveillance on a more detailed level.

The interaction

A rough simplification of the interaction between the regulator, the regulated, and the inspection office can be seen in Figure 3.1.

The interactions and corporations between the three seem not to be impossible. The interviews indicate that the cooperation between the three organizations works well and that there are honest communications and a closely working network. As described above, employees from Norway's, Denmark's and SCAA act as representatives and constitute the OPS-utvalget, which is the decision-making organ. OPS-utvalget further delegates the inspectorial duties to the STK.

STK works in close corporation with SAS, having almost daily contact and official external meetings with SAS every other month. According to the STK, SAS reports on occurrences that deviate from the normal procedures even though they easily would go unnoticed to STK.

SAS has its own inspection office in contrast to other Scandinavian airlines. Does this mean that SAS has a greater influence on the rules and regulations set by the SCASA? Or does it mean that they are being even closer monitored? Or does it simply imply that they do have this constellation because they are such a large airline so that the SCASA needs to have special recourses to be able to handle all inspection objects. This also raises the question of the regulator's role in this particular interaction. A societal regulator must keep societal requirements its first priority and too close personal cooperation between the regulated and the regulator may become worrisome in times of threats against safety.

At present the work on safety is in focus irrespective of this particular constellation of three organizations and their interactions. Janic (2000) refers evidence that indicating that despite a positive trend, it seems that it will be difficult to continue to reduce risks further in the most advanced organizations in the aviation industry. If this is true, the marginal gains in safety from improved safety management would be less conspicuous. Without experiencing strong improvement it becomes more important for management to keep an open and active communication encouraging staff in the air transportation industry to keep their positive attitude to work on safety.

II. A pilot perspective on safety

The following was based on an interview with a well-informed pilot with more than eighteen years of experience as a pilot with a major European Airline.

The aviation industry and its regulator

The safety authority carries the main responsibility of controlling the aviation industry through regulations and inspections in order to generate a safe industry. In general, the regulations set by the authorities related to the safety of aviation are less strict than those set by the major airlines. In line with this the European Airline (from here referred to as the airline) studies here, has stricter safety requirements than those set by the National safety Authority (from here referred to as the safety authority). Hence, regarded as having a higher level of aviation safety than required by the safety authority, which also, brings with it a high operational cost compared to smaller and low budget airlines, complying only with the regulation set by the safety authority. Safety is expensive and in order to maintain a high level of safety, resources and financial capacity must be available and remaining stable. Unfortunately, the recent losses in the airline industry have lead to difficulties in maintaining the safety requirements set by the airline itself, stretching its own stricter criteria for safe operations as a possible result. The low budget airlines were rapidly introduced to the market and this can be characterized by having very tight budget where marginal costs of safety action could result in decreasing the safety marginal.

The safety authority is active in suggesting regulation, which should be formulated and interpreted. However as shown earlier the safety authority states that the authorship and revision of regulation are not produced according to the currently fast development in technology. However, the information from the safety authority does not normally reach the pilots directly in the major airline we are focusing on here. Instead, information of revision of regulation from the safety authority is sent to the administration of the airline, which then provides the pilots with information about the revisions. This means that the information changing the internal criteria depend both in a revision of both the regulation set by the safety authority as well as by the airline itself. Hence, this makes it difficult for the pilots to determine which safety regulations or requirements they are required to follow, stretch or violate if this should happen. For transparency and confidence it is important to know which regulation and requirements belong to which organization. In the airline of the pilot, about 25 hrs/year are set off for the pilots to take part of the revision of the safety regulation. This is absolutely necessary and fundamental in order for pilots to stay up to date with the current regulation and safety requirements.

Inspections

As mentioned earlier, the safety authority is responsible for revisions of safety regulations and responsible for controlling that they are implemented. In doing so, safety inspection work is carried out with the purpose of discovering defects of safety-related issues. The inspections result in an inspection report, which is given to the airline after the inspection and contains information about how to correct and defects and whether the repair itself must be inspected. The safety authority needs increasing frequencies of inspections. At the same time they have difficulties in recruiting qualified inspectors and they have a shortage of competent and experienced inspectors.

One form of inspection work is based on the inspectors´ right to enter an aircraft unannounced to go on the flight to inspect and observe the pilots. The interviewed pilot had not once during his 18 years as a pilot been subjected to such an inspection. However, if such an inspection occurred the pilot considered it being more of an educational purpose for the inspector than an actual inspection of the pilot. The inspectors, in general do not have training on the specific aircraft model they are inspecting so aspects of human factors and general operational routines can only b addressed. This is just an illustration of the safety authority's need for improvements´ of their inspection work. It is also important to emphasize that in a trend of increased maintenance and inspection workload for the employees of the safety authority and a shrinking work force, it is even further important to stress the importance of well functioning inspections (Latorella & Prabhu, 2000).

Aircraft operation system state and process reports

Generally speaking, the 'perfect flight' does not exist. Pilots like any humans make minor and non-significant mistakes every day on every flight, not necessarily indicating an unsafe operations. To hinder such mistakes to develop into unsafe actions, the safety authority executes inspections and pilots are required to report all deviation from the 'perfect flight' to a data base of the airline, and in more sever cases also to the safety authorities. The reports are used in statistics in which trends can be derived. The trends are used to bring attention to specific technical defects and/or operation deficiencies needs improvement. Pilots and other personnel can then take advantage of this information and improve their operational knowledge.

Safety management philosophy of the airline

The aviation industry has come far when it comes to safety. Still, much is to be achieved in order to maintain the high safety level that exists. The safety authority performs inspections and an internal department of the airline performs quality controls. One such quality control is a simulator flight check twice a year. On each occasion the pilots are tested on different system components and human factors aspects (crew resource management). During two years, all system components should have been tested. About half of the time in a simulator check is used to ensure that a pilot fulfills the requirements for continue flying and about half of the time is devoted to training. The simulator flight control is not only about testing the pilots. If a mistake is made by a pilot the leader of the simulator check points out what the mistake was and the pilot is given a new chance performing the task. It should be noted that during the simulator check the instructor does not only check the pilots' knowledge about different systems, but great weight is also given to a pilot's ability in terms of cooperation, group interactions and problem solving.

The general attitude within the airline is that humans including pilots and other staff make mistakes but that they also can learn from the mistakes. Therefore the simulator

flight control is regarded as a learning opportunity and not only a test in which the pilot can fail.
Another example of learning opportunities is the so-called 'line-check'. The line check takes place once a year. An experienced pilot (instructor) accompanies a crew on a flight in order to check and evaluate the pilot's work routines. After the flight, a group discussion follows in which pilots with the instructor discuss the different difficulties and mistakes during the flight and possible solutions and improvements. The line check is also used for dissuasions about new procedures and reasons for changes of procedures.

The Airline and Internal Feedback

As well as having an organizational culture that emphasizes learning through experience, a functional internal feedback system that builds on communication and interaction is as important in order to generate good safety management.
One feedback routine that illustrates a well functioning internal feedback system is the use of the logbook system. Each aircraft had its own logbook, which the captain is required to fill out for each flight. This information is then further passed on to the next flight shift and the maintenance department. Documentation on technical malfunctions or disturbances is notified in detail, when and where it occurred, if the needed counter measures were taken and within what time frame the malfunction should be repaired. To illustrate, the pilots we interviewed had, for example, once forgotten to report in the logbook and he had left the airport without passing the information on to the next shift. He was therefore contacted in order to orally from a distance report to the pilots who were in charge of the next flight. Only after having received that information was the next flight crew allowed to continue the flight because the logbook of the previous flight has not been documented. Even if there is nothing to report, the pilot has to report a 'NIL' or 'no further' with reference to an earlier log report to verify that nothing is to report. This example demonstrated a well functioning internal feedback system.
Another routine that is part of the pilot's work routines is the external inspection of the aircraft prior to take off. Earlier the technicians did this but thus task has rather recently been moved to a duty of the pilots. The airline company had made a judgment, that after having completed a required course each pilot will be able to conduct the external inspection. However, the pilot's consider technicians to be better trained for this task: it is obvious that pilots today do not have the same experience and knowledge as the technicians to perform these external inspections. In fact, some pilots do not feel completely secure about their own inspections.

The Airline and External Feedback

Not only is it important that the internal feedback is effective and well functioning, external feedback systems that are communicated between the airline, the safety authority and the air traffic control just to mention a few are equally important for the systems' ability to close the feedback circle. The logbook system, mentioned above, enables recurrent faults to be discovered so that the specific component that is frequently reported in can be paid further and more in depth attention to. This would create the necessary conditions for the safety authority to conduct statistics over different faults over longer periods of time, an external feedback loop that in addition to the internal feedback system will be an open communication feedback loop.

4. The Norwegian Petroleum Directorate, the regulating authority for Norwegian petroleum activities: A selective review of safety management

4.1 Introduction

Offshore petroleum activity is risky business, and there are several ways in which safety is put in risk. On a global level drying wells implies several threats to welfare, among them decreasing energy supplies and economies. The other way around, petroleum activities can threaten the environment by emissions to the air and pollution of the seas which in a longer run (a run that over the years may have become relatively shorter) seriously threatens, for example, the global warming and ecosystems. Somebody has to take responsibility of these threats and manage the safety in a way that the risks of threats do not become realities. On a national level we have authorities that regulate safety in companies and controls that the legislation is fulfilled in the activities controlled. The regulating authority for petroleum activities on the Norwegian continental shelf is the Norwegian Petroleum Directorate-NPD.

There are many possible approaches to safety, both theoretical and practical. Safety culture is one important factor sometimes used as an indicator of safe operations in organizations. In a selective review Svenson and Salo (2001) disseminated various themes of organizational culture and safety culture. Although the concept safety culture is defined differently in different contexts it seems to include some important attributes that are common in many contexts, such as shared ideas, values and behavior (Salo and Svenson, 2002; Jacobs and Haber, 1994). Safety culture may be partly described by how safety is managed in the organization. In spite of being a part of safety culture it is very important as such. Svenson and Salo (2003) argued that the efficacy with respect to safety of the prevailing management policy could be traced back from the consequences of specific activities up to the management of those activities. In a top-down perspective, the effects of an adopted safety policy can be followed through several stages, for example: objectives, planning, orders, implementations, benchmarking, feedback etc. Thus, the study of safety management may be a way of moving safety research to a more general level (Svenson and Salo, 2003).

Today, safety management in offshore activities is studied from various perspectives. According to Gordon (1998) highly complex socio-technical systems are dependent upon the interaction of technical, human, social, organizational, managerial and environmental factors, which together can contribute to catastrophic events. Safety performance is these terms are often illustrated in analyses of accidents such as the Piper Alpha disaster.
There are increasing demands to bring not only technological factors in calculations of safety in offshore structures, but also organizational and human factors. People are involved in all life stages of a structure. Robert G. Bea (1998) discusses concepts and engineering approaches to improve reliability of offshore structures including people. He argues that real time safety management, and a development of a safety management assessment system is important issues for safety improvement.
Safety management assessment systems that have been tested in field include (for example) the Safety Management Assessment System (SMAS) that was developed to

assess mainly marine systems including offshore platforms (Hee, Pickrell, Bea, Roberts, and Williamson, 1999). The assessment process is computerized. The assessment models a system on several levels. First a system is identified by components comprising a given system called *modules* (e.g., operating teams, organizations, procedures, etc.). Each module includes several factors (*for the organization module* e.g., process auditing, safety culture, risk perception, communications etc.), and each factor can be described by several attributes (*for the communications factor* e.g., same language, established forms, feedback, etc.).

How management of safety is practiced is related to the organization's safety performance. Mearns, Whitaker, and Flin (2003) studied safety climate, safety management practices and safety performance in offshore environments. They found associations between safety climate and official accident statistics, and also reporting frequency. The results showed that proficiency in some safety management practices was associated with lower accident rates and fewer respondents reporting accidents. Also individual leadership and managerial styles has been identified to affect safety management. Results from one study on site managers safety leadership in the offshore and gas industry (O'Dea & Flin, 2001) has shown that although managers are aware of what is the best practices in managing safety, their actions does not necessarily follow their awareness. It seems as if less experience and more directive leadership styles are more associated with overestimations of the own ability to influence the own workforce. The authors suggest improvements to be made in several areas, for example, standardization of safety culture, and harmonization of practices across industries, workforce competency and involvement in safety activities and decision-making.

Today there seems to exist two general approaches to safety, one technological and one organizational. There are several reasons for making efforts to close the gap between organizational explanations and technological explanations of safety. We believe that high reliability organizations will benefit more in the long run from integrated knowledge structures than from separated knowledge structures. One possible key to integration is systems theory. Svenson and Salo (2003) argued that: "…safe operations are usually described according to the technological system structures and/or system components existing in the particular industry where the safe operations in question shall be carried out. This approach is fundamental for several reasons. For example, in ideal systems a systems perspective allows identification of deviations from a steady state related to known safety standards of different subsystems and/or components of the systems, through feedback channels, giving opportunity to a prerequisite of countermeasures to correct the deviation. From this perspective it is also possible to trace and identify consequences to various alerts, both individual human, organizational and/or technological. By applying a system approach we can link different measurable units of consequences to actions" (Svenson and Salo, 2003, p 22).

According to Miller (1978), the highest system level is the suprasystem. In the context of the present study the boundaries of the suprasystem is defined by the scope of the study. If we are going to study "petroleum activities on the Norwegian continental shelf", this also makes up the boundaries. The suprasystem is kept in steady state by subsystems that can be both non-living (e.g., technical systems) and living (e.g., persons, organizations). Except structures, a system consists of processes, information driven by energy that can be observed by changes in the structure. Both structures and processes are needed for the explanation of each other. The steady state is described by all including variables within a prescribed range. During normal circumstances, when variables are drifting away from the prescribed steady state, the system counteract with negative feedback to operate the system back to steady state. Adjustment rely on various information feedback within and between the suprasystem, subsystems, and the environment surrounding the suprasystem (Svenson and Salo, 2003). This gives a general systems framework towards which organizational structures can be modeled. In the present study we will also attempt to place a systems perspective to the analyses of safety management.

4.1. Aims of the study

This study aims on describing safety management in the Norwegian Petroleum Directorate.
The purpose with this chapter is not to perform full-scale document analyses, but rather selectively pick up themes from available documents that we believe are relevant for safety management from a systems perspective. These themes are (1) structure of the organization, (2) regulations in relation to safety management, (3) threats to safety, and (4) information management and feedback. We hoped to obtain aspects of safety management that was unique or characterizing NPD that can inspire future activities for an enhanced safety management. Most of the documents were available from the NPD website, and many of them are only available from the site since NPD turned "paperfree".

4.2 Method: Document analysis

The analyses were based mainly on the following documents: (a) NPD´s organization, (b) Service declarations, (c) Collaboration projects, (d) Rules and regulations, mainly the framework regulations and the management regulations, (e) NPD's Annual report 2002, and (f) Facts about Norwegian petroleum activities 2003 from the Oil and energy department.
Documents *a-c*, are public information put forward by the NPD and is available in html documents on the NPD website. Documents *d*, are the collection of NPD regulations for petroleum activities. Documents *e* and *f*, are annual publications from NPD and MPE. Many documents are only available from the NPD website following the "paperfree" policy.

This study was conducted during 2003. NPD had recently been engaged in a process of organizational change and the organizational structures were not fully settled at the time of the investigation. From this point of view the results reflects a snapshot of the NPD organization at the time the investigation was made.

4.3 Results from the document analyses

This section starts with giving a background to the Norwegian petroleum activities. The background consists roughly of three parts. First a historical review illustrates how a venturesome idea about Norwegian oil production during a few decades grew to a "third in the world" position. Second, we will describe the Norwegian states organization concerning petroleum activities. Third, objectives and duties of the NPD will be

presented. This makes up the background to which helps identification of NPD and its relations to other structures.
After the background data, the results section continues with analyses of the three themes of safety management (1) The structure of NPD´s organization, followed by a discussion about regulations related to safety management, (2) Identified threats, and finally (3) the Management of information. Each of the three themes ends with a concluding summary.

4.3.1 A brief history of the Norwegian petroleum activities

The following Norwegian oil history is based mainly on "Fact Sheet 2002 Norwegian Petroleum Activity", published by The Ministry of Petroleum and Energy-MPE (Olje- og energidepartementet, 2002).

Today, petroleum operations play a substantial role in Norway's economy, and contribute considerable revenues to the state. After Saudi Arabia and Russia, Norway today ranks as the world's third largest exporter of crude oil. However, it was not many decades ago people did not think that Norwegian petroleum activities could be a lucrative enterprise. It was not until the discovery of gas at Groningen in the Netherlands in 1959 geologists started to ponder over petroleum potential beneath the North Sea.

In 1962, the Phillips Petroleum oil company was first out to apply for permission to conduct geological surveys. On the 31 May 1963 Norway proclaimed sovereignty over petroleum activities on the NCS (Norwegian Continental Shelf). In a new statute it was determined that the state owns any natural resources on the NCS, and that the Crown alone is authorized to award licenses for exploration and production.
In the same year, companies were granted reconnaissance licenses to perform seismic surveys, but not to drill. In agreements in 1965 by Norway UK, and with Denmark, the North Sea was divided in accordance with the median line.

The first offshore licensing round was announced in 1965. The first well was drilled off Norway in the summer of 1966 but it proved to be dry.
Since the early 1970s the key goals for Norwegian oil and gas policies have been National management and control, building a Norwegian oil community and state participation.
The Storting (parliament), the government, the ministry and a new state agency –the Norwegian Petroleum Directorate (NPD), would administer the petroleum operations. The Norwegian Petroleum directorate NPD (Olje Direktoratet) was resolved by the Norwegian parliament in 1972.

Foreign multinational companies initially dominated the off Norway exploration and the development of Norway's first oil and gas fields. A state-owned oil company *"Statoil"* was created, with initially 50 per cent state participation in each production license. The percentage and forms of state participation have been reorganized a number of times over the years.

The first development off Norway ceased its production in May 1993 (North-East Frigg gas field), and in January 2002 totally 12 fields had been shut (MPE, 2002). Today, the oil production has exceeded the volume of new discoveries for a long time. The same situation is also true for the gas production. Hopefully good resource management will result in gains. A report to the parliament on oil and gas activities outlined two future scenarios – one of decline and one of long-term. The difference between the scenarios was approximated to more than NOK 2 000 billion up to 2050, at today's oil prices (2003:6). A challenging enterprise for Norwegian petroleum activities though, it is not history but future.

4.3.1.1 Important Norwegian petroleum activities over the years

Several important Norwegian petroleum activities during the years are summarized in Table 4.3.1 below. It gives not only a picture of the scale of the petroleum activities on the NCS, but, accordingly, also the dimensions of the NPD activities.

Table 4.3.1: Summary of important Norwegian petroleum activities over the years (MPE, 2002).

North Sea		
Year	**Field**	**Activity**
1967	Balder	Discovered
1969	Ekofisk	Proven
1970		Several finds in the area – a large discovery
1971		-Norwegian North Sea oil production begins
	Frigg	-Discovered, on stream 6 years later
1974	Statfjord	Discovered, shared between Norway and UK, on stream 1979
		-Dry gas export pipeline built to St Fergus in Britain
1975		Norpipe pipeline to UK completed
1977		Norpipe system's lean gas line from Ekofisk to Emden become operational
1984	Oseberg	Approved, production start 1988, oil piped to Sture near Bergen
1985	Statfjord	Trunkline to Kårstø north of Stavanger, condensate removed before lean gas is pipelined to Europe
1986	Sleipner East and Troll Phase I	Gas developments approved by the parliament, gas is becoming increasingly important in overall Norwegian petroleum production.
1980s-1990s	Statfjord, Gullfaks, Snorre and several smaller fields (Tampen region)	
1995	Troll	Second phase approved, on stream, crude from Troll is piped to Mongstad near Bergen.
Norwegian Sea		
1980		The first three production licenses above the 62nd parallel awarded in 1980
1981	Midgard,now part of the Åsgard field (Halten Bank)	Petroleum discovered
1988	Draugen	First oil field approved for development on the Halten Bank, on stream in October 1993
	Heidrun, Njord, Norne and Åsgard	Subsequently come on stream.
1992		Parliament approved construction of the Haltenpipe gas transport system from Heidrun to Tjeldbergodden
1995	Heidrun	On stream, associated gas from this field has provided feedstock for

		methanol production at Tjeldbergodden since 1997.
	parts of the Møre and Vøring areas	Deepwater areas of the Norwegian Sea were put on offer
1997	e.g. Ormen Lange	Large (deep water) discoveries confirmed that the area has great potential. One of these was, the second-largest gas discovery on the NCS, with 400 million scm of gas.
1998	Åsgard	Transport system was given the go-ahead in 1998, operational 2000. It ranks today as the only gas export trunk line from the Halten Bank.
2001	Kristin and Mikkel	Plans for development and operation (PDOs) approved
	Åsgard	Two small lines tied into Åsgard Transport - the Norne and Heidrun Gas Export systems - become operational
Barents Sea		
		39 production licenses have been awarded in the Barents Sea since 1980, minor and medium-sized gas discoveries.
2000		The Goliat oil discovery
2001		Plans for development and operation (PDO) and installation and operation (PIO) for the Snøhvit LNG project were submitted to the authorities
2002		Approved by the Parliament

4.3.2 The Norwegian state organization of petroleum activities

The framework for petroleum operations in Norway is determined by the Norwegian parliament. The parliament approves major development projects or issues of principle. Authority to approve development projects with an estimated cost of less than NOK 10 bn is delegated to the King in Council. The *Ministry of Petroleum and Energy* – MPE (Olje- og energidepartementet) has the overall administrative responsibility for petroleum operations on the NCS. MPE has the responsibility to ensure that operations follow the parliament guidelines.

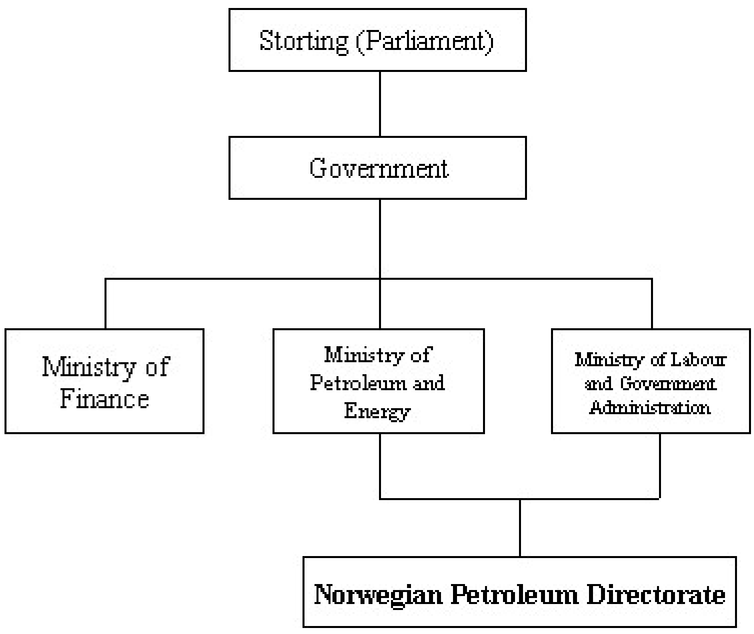

Figure 4.3.2: The state organization of petroleum operations (MPE, 2002, p 15).

The MPE is organized in four departments with each department, in turn, organized in sections (in parentheses). The departments cover: *E&P and market* (oil, gas, exploration), *petroleum* (environmental affairs, industry, state participation, economics, petroleum law and legal affairs), *energy and water resources*, and *administration, budgets and accounting* respectively. E&P and market and petroleum departments are responsible for petroleum operations (see figure 4.3.2 above).

The overall responsibility for the working environment in the petroleum sector, and for emergency response and safety aspects of the industry, rests within the *Ministry of Labor and Government Administration*.

NPD is administratively subordinate to the MPE, but reports to the Ministry of Labour and Government Administration on issues relating to the working environment, safety and emergency response (MPE, 2002, p 16).

NPD is located in Stavanger with a regional office in Harstad. The employment figures at the end of 2002 were 346 people and an additional 17 employees were on leave. The percentage of women/men was 44/56. Fifteen employees were hired in permanent positions. Of these, six came from oil-related activities. Thirteen permanent employees have left their positions, four of these as retirees. The percentage female managers were 30% (MPE, 2002).

4.3.2.1 Norwegian state participation

The Norwegian petroleum resources belong to the Norwegian community and should be managed for best possible benefit both in the present and in the future. It is an important objective that larger parts of the profit return to the community. An instrument for this policy is the *state's direct financial interest* (SDFI), which was created in 1985 when Statoil's license interests on the NCS were split into two financial components, one for the state and one for the company. In state participation after 1993 (after the 14th round) the SDFI receives a holding in each production license that reflects the profitability at the time the license was created. In some licenses the SDFI holding is 0 %. In 2001 the parliament decided to restructure the participation in the petroleum sector, an enterprise directed towards partial privatization of Statoil. Statoil was in 2001 introduced to international the stock market with 18.2% of the company (MPE, 2002).

Besides Statoil AS there are two other companies created for the SDFI. Petoro AS, who manages the SDFI on behalf of the state, and is the company who owns the SDFI portfolio, and AS which is a company for transport of natural gas and is wholly state owned. Gassco was created at the time Statoil became partly privatized.

4.3.3 Objectives and duties of the NPD

The Norwegian Petroleum Directorate shall contribute to creating the highest possible values for society from oil and gas activities founded on a sound management of resources, safety and the environment (NPD, 2003:1).

NPD answers mainly to three ministries regarding different matters: (a) resource management and administrative matters (the Ministry of Petroleum and Energy), (b) matters relating to safety and working environment (the Ministry of Labor and Government Administration). (c) NPD also exercises authority on behalf of the Ministry of Finance within the area of CO_2 tax (NPD, 2003:1).

NPD has three primary functions: (a) “to exercise administrative and financial control to ensure that exploration for and production of petroleum are carried out in accordance with
legislation, regulations, decisions, licensing terms and so forth”, (b) “to ensure that exploration for and production of petroleum are pursued at all times in accordance with the guidelines laid down by the MPE”, and (c) “ to advise the MPE on issues relating to exploration for and production of submarine natural resources” (MPE, 2002, p 16).

The NPD identifies several important tasks for their activities. It is regarded as important to have "the best possible knowledge" concerning discovered and undiscovered petroleum resources on the Norwegian continental shelf. NPD carries out supervision both in order to ensure that the "licensees manage the resources in an efficient and prudent manner", and also by regulatory means, to establish, maintain and further develop a responsible safety level and working environment. It is also regarded as important to influence the industry to develop solutions that are serving the "interests of society as a whole" (NPD, 2003:1).

“NPD provides advice to supervising ministries and has been delegated the authority to issue regulations and make decisions regarding consents, orders, deviations and approvals pursuant to the regulations (NPD, 2003:1).

Environmental issues are considered important, and NPD strives to make Norway leading in this issue. Another important function is to provide both the industry and the public and the media with neutral information about petroleum activities (NPD, 2003:1).

4.3.4 The structure of NPD´s organization

From January 1, 2001 a prior hierarchical organizational was replaced with a flat organization (see figure 4.3.4a). The renewal was partly inspired by the Norwegian governments program for renewing, reorganizing and enhancing the efficiency of Norway's public administration (NPD, 2003:2). The characteristics of the new flat organization are shown in Table 4.3.4a.

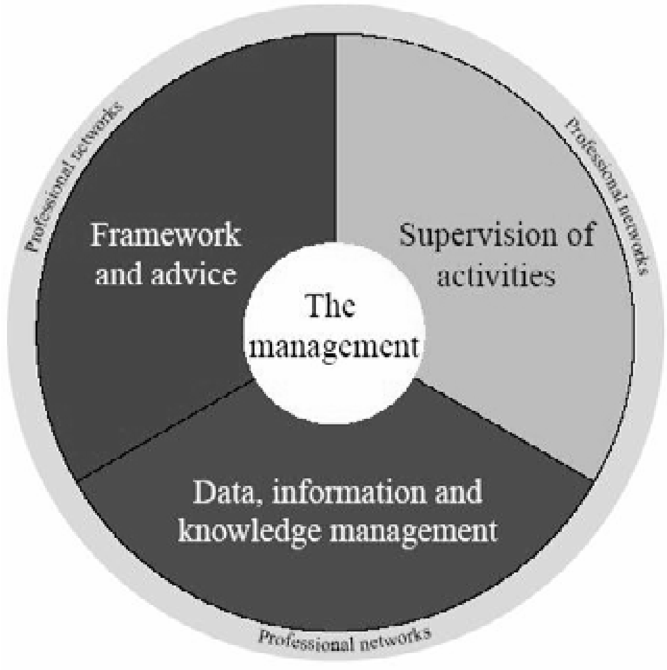

Figure 4.3.4a: NPD organizational chart (NPD, 2003:2)

Table 4.3.4a: Themes characterizing the NPD organization (NPD, 2003:2).

The organization: - is flat and based on flexible, multidisciplinary and collaborating teams organized around priority products - is focused on developing the expertise of NPD staff - places responsibility for product, quality and process with the teams - focuses systematically on optimizing and enhancing the efficiency of internal processes - has few senior managers, who focus primarily on unified strategies, processes and planning - will be further developed with the aim of basing organization and production of services on user needs - gives a central place to developing a common culture and values.

The new flat organization is constituted of three "product areas". The product areas are:
(1) *Framework and advice*, "which will develop and propose overall terms for the petroleum sector in cooperation with the authorities, the industry and the unions". They provide decision advice to the Ministries of Petroleum and Energy and Labor and Government Administration.
(2) *Supervision of activities* is responsible for that actors observe and understand the framework conditions for petroleum operations on the Norwegian Continental Shelf (NCS).
(3) *Data, information and knowledge management* takes a national responsibility to provide petroleum sector data to the NPD partners and to the public. They also develop, integrate and distribute knowledge from the petroleum industry (NPD, 2003:2).

4.3.4.1 National and international cooperation

NPD has cooperates with several organizations both nationally and internationally. The (national) cooperation is organized in a number of collaboration projects (samarbeidsfora) focusing various areas relevant for the NPD. Table 4.3.4b shows collaboration projects that NPD takes part in (2003:4). In addition NPD is active in international cooperation cooperation with several countries (Angola, Bangladesh, CCOP, Mozambique, Namibia, Nicaragua, Russia, South Africa, Timor-Leste, Vietnam).

Table 4.3.4b: NPD collaboration projects (according to NPD, 2003:4).

Safety forun (Sikkerhetsforum)
The safety forum is the central co-operational arena between parts of the industry and authorities regarding HMS.
The safety forum is directed by NPD who also hold the secretarial post. The safety forum includes representatives from:

- -Norwegian Petroleum Directorate (NPD) (chair and secretariat)
- -Ministry of Labour and Government Administration (AAD) (observer)
- -Norwegian Oil and Petrochemical Workers' Union (NOPEF)
- -Federation of Oil Workers' Trade Union (OFS)
- -Norwegian Confederation of Trade Unions (LO)
- -Lederne
- -LO Industri
- -Cooperating Organizations (DSO)
- -The Norwegian Oil Industry Association (OLF)
- -Norwegian Shipowners' Association
- -Federation of Norwegian Engineering Industries (TBL)

Cooperation for safety (Samarbeid for Sikkerhet, SfS)
The project Cooperation for safety was established 2001/2002. The participants from both the employers and employees organizations has a common goal to improve safety related to human actions onboard vessels and installations, and to put the focus on all affecting circumstances. NPD are represented as observers. Among the participant organizations are: Lederne, LO, Norwegian Shipowners' Association, NOPEF, OLF, TBL, and DSO.

CDRS
The CDRS is a common database established in September 1999. The database contains drilling information from all wells drilled on the Norwegian Continental Shelf since 1984.

DISKOS
The DISKOS data repository is a data management system which has been designed to store corporate and national data. Thus, data from the Norwegian continental shelf are found in the national petroleum data store in Stavanger.

FORCE
The objective of FORCE is to provide structured opportunities for the participants to discuss, with each other and with research and technology providers.

FUN
FUN is a forum for oil companies and authorities in Norway that focuses on matters related to forecasting and uncertainty evaluation of future oil and gas production. The forum, which was established in May 1997, has 18 member companies plus the Norwegian Petroleum Directorate (NPD).
FUN includes representatives from: BP, Mobil, Norsk Hydro, Saga, Shell, Statoil, and the NPD.

NIGOGA
NIGOGA is an electronic document containing guidelines for the performance and reporting of organic geochemical analyses of well samples (rocks and fluids) as applied in the Norwegian petroleum industry. Thirty-two laboratories from Europe, USA and Australia participated in this project.

4.3.4.2 Service declarations

This section describes the NPD service declarations (serviceerklæringar), which gives a description of what to expect in the interaction between NPD and the licensee. From that perspective it is illustrative for systems interactions. From a more narrow perspective, service declarations are one part of the information management system. We have chosen to present this section under the heading of NPD's organization, but it could also be part of the information management section presented below.

Service declarations are central means for improving the service and the user orientation of the state administration (NPD, 2003:3a). The main purpose of the declarations is to provide the users information about the services provided by NPD. They are based on NPDs opinion about their own tasks and the needs and demands of the users. Important parts of the service declarations are summarized under the six headlines below. The first headline (*Supervision of safety and work environment in petroleum operations*) is central to safety management and will receive extra attention.

Supervision of safety (tryggleik) and work environment in petroleum operations is based on the regulations of health, environment and safety (HES) in the petroleum activities act (the framework regulations) with four regulations**:** the Management Regulations, the Information Duty Regulations, the Facilities Regulations, and the Activities Regulations. The acts were issued by NPD together with the Norwegian Pollution Control Authority (SFT) and the Norwegian Board of Health (NBH) on 3 September 2001. 60000 hours of supervision (tillsyn) is made per years by the NPD (NPD, 2003:3b).

In revisions and verifications one group is identified as responsible for the activity that is going to be investigated. (a) Three weeks before the supervision takes place, the activity that is going to be supervised receives a written notice about the activities that will be included in the check-up, and are also asked about documents that will be included in the. (b) The activity of supervision starts with an orientation about the goals and the content. (c) This is normally followed by interviews with representatives for the supervised activity. In addition, verifications of documents and equipment, or gathering of additional information are carried out. (d) The activity supervised is requested to have an observer available during the entire supervision. The results will be announced during a meeting where details of observations will be given and anything still unclear will be solved. (e) Three to five weeks after this, a report will be published. (f) The supervised activity will receive a report together with a reminder about duties and possible sanctions. There is time to complain about the sanctions. (g) When agreement is received, a written announcement that the activity of supervision is finally closed will be sent out.

When the supervising activity is directed towards incidents, jeopardizing safety and working environment, a very short notice is given. The procedure that follows resembles the one for verifications (above). In cases of police investigations the NPD will assist with technological or other expertise. This is a parallel activity and should not influence the regular supervision activity.

The operators shall receive consent from the NPD before:
-Investigations including drilling to a depth of 200m bsl are carried out.
-Exploration drilling.

-Manned underwater operations.
-An installation or parts of it is taken into operation.
-Rebuilding or changes of installations.
-Plans to continue operation of an installation exceeding its "lifetime" or other things that are anticipated.
-Availability of an installation, possible removal of an installation not enclosed by the petroleum law.
-Removing of or changing the use of a vessel that has a significant safety related function related to the petroleum activities.

The normal handling time is nine weeks. In cases of when the licensee will carry out activities that does not correspond to specified regulations, the licensee must apply for dispense (NPD, 2003:3b).

The service declarations on *working hours and settlements about working hours* gives advice on when and how the operators shall manage stay and off-duty periods. This includes, for example, time limits for when NPD shall be contacted about extended work time periods (NPD, 2003:3c).

The fact pages and announcements about production figures on NPDs homepage. NPD makes efforts in making information available to the users. One important instrument for this activity is the NPD homepage. The homepage will include fact pages with updated information about production licenses (for example, first time registrations), *wells* (for example, bore programs, daily reporting from well activities, other communications between operator/licensee), and *production figures* from NCS (based on monthly reporting from the operating companies. The fact pages make it possible to download data files that can be used in datasheets and other programs for further calculations (NPD, 2003:3d).

(4) *Inquiries about* (public-) *insight*. NPD gives advice about insight in public documents and points to the laws and regulations concerning, for example, *the principle of public access to official records* (offentlighetsprinsippet), and the *the laws that regulate public access to official records* (offentleghetsloven). A public journal is available on the homepage for at least one week, and older journals can be required from the NPD main archive. Inquiries about (public-) insight shall be handled in one to three days and in extra ordinary cases not more than eight days (NPD, 2003:3e).

(5) *The petroleum register* is a register of all production and pipeline licenses. This service declaration gives advice, for example on documents that should be included in transferences, pledges, change of company names etc (NPD, 2003:3f).

(6) The service declaration for the *Library service* gives advice on library resources and how various documents can be acquired externally. The library includes 16 000 books, reports, conference documents and 300 journals covering various areas relevant for petroleum activities, such as: petroleumgeology, geophysics, production of oil and gas, laws, safety, etc. About 50% of the documents are available in English (NPD, 2003:3g).

4.3.4.3 Summing up: NPD from a systems perspective

There are several possible suprasystems from which petroleum activities can be modeled. Possible suprasystems might be, for example: petroleum activities in the North Sea including other regulators than NPD, European petroleum activities, on-shore activities excluded and relevant regulators, etc. This study aims at describing NPD in relation to petroleum activities on the NCS. The boundaries for the suprasystem are, accordingly, petroleum activities on the NCS. We argue that both the NPD and the MPE perspectives are needed to model NPD as one sub system of the suprasystem.

First, the arguments are based on an interpretation that NPD emphasizes a systems perspective when describing the own organization's interactions with licensees, collaborative projects, and the public (subsystems/structure) and the information exchange needed in the interaction (process). The licensees are easily illustrated as companies acting on the NSC, and constitute one and each an individual subsystem. The collaborative projects were illustrated by an identification of both national and international cooperation projects labeled "fora", and the tasks that identifies the interaction with the fora. This is, however, not completely straightforward for a systems analysis. The identified cooperation projects (fora) are not as stable over time as the structures of the collaborating parties (e.g., employees organizations, companies, departments, etc.) included in the projects. From one perspective a forum can be modeled as a process that the parties engage in, from another perspective a forum is a structure, however temporarily manifested, that may have substructures resembling "real" subsystems.

Another problem for our analysis is that the documents we analyzed did not reveal a sufficiently detailed internal structure of the NPD. There are only three levels at hand: (1) the flat organization, (2) consisting of the three product areas, (3) including multidisciplinary and collaborating teams organized around priority products. We do not know how the teams are organized, how the interaction works within or between substructures, how boundaries for management is organized at different levels etc. This brings about that no detailed analysis of the internal processes between NPD substructures can be made.

Second, the arguments are based on an interpretation that MPE also emphasizes a system approach to its activities and interactions, and in addition models enclose NPD in the activities (NPD is organizationally sub ordered MPE). The basic functions of NPD is to exercise authority (regulate) legislated in higher-level organizations (MPE and higher) in one direction, and answer back to the ministries, among them MPE (advice and feedback). It is only in this context that the NPD become identifiable and interpretable from a systems perspective. The regulating activity is based on the petroleum regulations. However, we have decided to discuss regulations in the context of safety management (below).

Figure 4.3.4b models the suprasystem "petroleum activities on the NCS" according to Leveson's (1995) and Miller's (1978) system definitions. It includes two basic subsystems: NPD and the companies. In addition the subsystem "state and crown" is located above the NPD. The dotted ellipse indicates temporary structures such as cooperative projects. Arrows indicate system input and output, subsystem interaction, and interaction between the suprasystem and the environment.

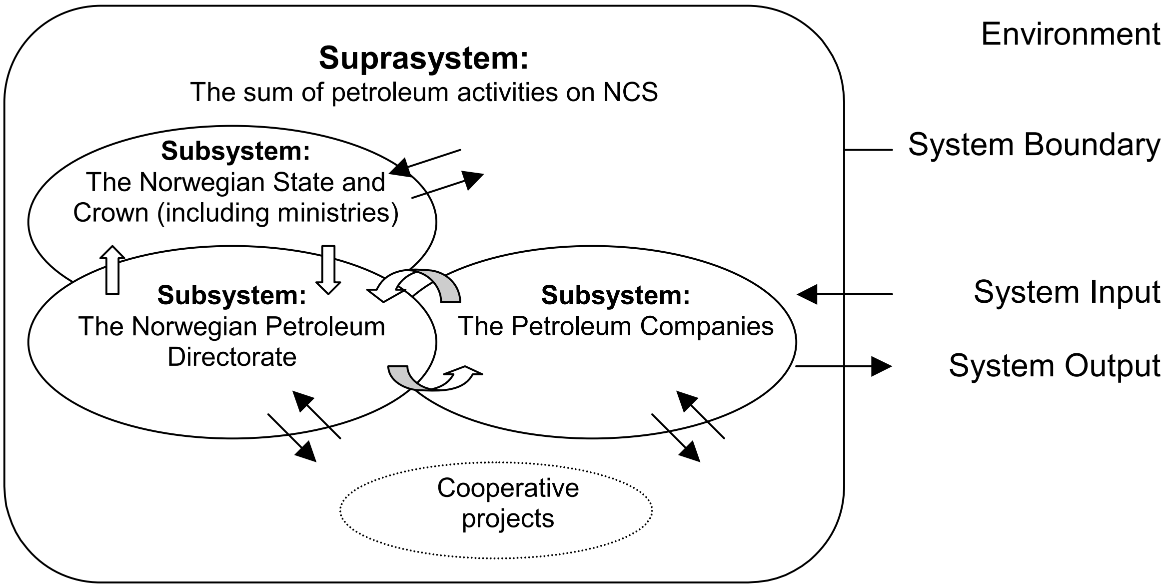

Figure 4.3.4b: System model of petroleum activities on the NCS according to Leveson's (1995) and Miller's (1978) definitions. Interaction and system input/output are illustrated with arrows.

4.3.5 Petroleum regulations

The following section is based on an "unofficial" English version of the petroleum regulations (yet available on the NPD site). NPD emphasizes that any disputes shall be decided on the basis of the Norwegian text (NPD, 2003:5).

Norwegian petroleum activities are, basically, regulated through five regulations (in force Jan 1, 2001). The regulations are: (a) Regulations relating to Health, Environment and Safety in the Petroleum Activities (the Framework Regulations), (b) Regulations relating to Management in the Petroleum Activities (the Management Regulations), (c) Regulations relating to Material and Information in the Petroleum Activities (the Information Duty Regulations), (d) Regulations relating to the Design and Outfitting of Facilities etc. in the Petroleum Activities (the Facilities Regulations), and (e) Regulations relating to Conduct of Activities in the Petroleum Activities (the Activities Regulations) (2003:5a).

In addition to the five regulations there are corresponding guidelines, which are not legally binding. They should be considered jointly in context to obtain the best possible understanding of what the authorities wish to achieve through the regulations (2003:5a).

The Norwegian Pollution Control Authority, the Norwegian Social and Health Directorate and the NPD co-operate on joint, total regulations relating to health, environment and safety (HSE) on the NCS (NPD, 2003:5).

4.3.5.1 What are the regulations telling about safety management?

A closer examination of the regulations gives us a hint about how management of safety is regulated in the petroleum regulations. Two of the five regulations are considered as more relevant in this context: (1) the frame regulations, because it "provides a framework for coherent and prudent petroleum activities", (2), the management regulations, because it "assembles all overarching requirements as to management in the health, environment and safety sphere" (NPD, 2003:5a). To begin with, several chapters of the *framework regulations* are directed to themes of safety management. We have selected and focused on 6 themes (1-6, below). The themes are not expressed explicitly in the regulations, but are constructions of the authors. Some examples of sections from relevant chapters in the regulations are presented in excerpt below (indicated by dots preceding or ending the particular excerpt). There are two themes in the framework regulations that we consider as important in relation to safety management. Here we will highlight the encouragement of individuals and the organization to contribute to safety management. After the presentation of the excerpts from the regulations, the interpretation of the regulations related to each theme is summarized.

4.3.5.2 The framework regulations

1. Everybody shall contribute to safety management

> *Chapter II: TO WHOM THE REGULATIONS ARE DIRECTED AND REQUIREMENTS TO EMPLOYEE CONTRIBUTION,*
> *Section 5, Responsibility according to these regulations*
> …The operator shall see to it that everyone carrying out work for him, either personally, by employees, contractors or sub-contractors, complies with requirements contained in the health, environment and safety legislation…
>
> *Section 6: Arrangements for employee contribution*
> The party responsible shall ensure that the employees and their elected representatives are given the opportunity to contribute in matters of importance to the working environment and safety of the enterprise according to requirements contained in and pursuant to the Working Environment Act and these regulations…
> … it shall be ensured that the employees and their elected representatives are given the opportunity to contribute in the establishment, follow-up and further development of management systems as mentioned in these regulations Section 13 on duty to establish, follow up and further develop a management system…
>
> *Chapter IV: MANAGEMENT OF THE PETROLEUM ACTIVITIES*
> *Section 13: Duty to establish, follow up and further develop a management system*
> The party responsible shall establish, follow up and further develop a management system in order to ensure compliance with requirements contained in the legislation relating to health, environment and safety…
> …The employees shall contribute in the establishment, follow-up and the further development of management systems….

It can be interpreted that safety management according to the framework regulations implies that everybody working at the licensee, contractors or subcontractors shall comply with stated requirements. The employees shall be given opportunity to contribute to working environment and safety, and in the establishment, follow up, and further development of management systems.

2. The organization and culture is important for safety management and everybody should contribute to its maintenance and development

Chapter III: PRINCIPLES RELATING TO HEALTH, ENVIRONMENT AND SAFETY
Section 9: Principles relating to risk reduction
… Assessments on the basis of this provision shall be made in all phases of the petroleum activities. In effectuating risk reduction the party responsible shall choose the technical, operational or organisational solutions which according to an individual as well as an overall evaluation of the potential harm and present and future use offer the best results, provided the associated costs are not significantly disproportionate to the risk reduction achieved…

Section 10: Organisation and competence
The operator shall have an organisation in Norway which on an independent basis is capable of ensuring that petroleum activities are carried out according to rules and regulations…
…The Norwegian Petroleum Directorate may by individual decisions or regulations require changes to be made in the organisation of petroleum activities, including the composition and number of personnel.

Section 11: Sound health, environment and safety culture
The party responsible shall encourage and promote a sound health, environment and safety culture comprising all activity areas and which contributes to achieving that everyone who takes part in petroleum activities takes on responsibility in relation to health, environment and safety, including also systematic development and improvement of health, environment and safety.

It can be interpreted that safety management according to the framework regulations implies that the principles related to risk reduction shall take into account not only technical and operational solutions but also organizational, and that assessments shall be made in all phases of petroleum activities. The operator is responsible for that the own organization complies to the regulations and that NPD can make decisions of changes in the operators organization. The responsible part shall promote the development of a sound health, environment, and safety culture in all aspects of the petroleum activities, and encourage everybody to take part in such activities. All excerpts above are collected from the framework regulations (2003:5b).

4.3.5.3 The management regulations

We continue with examining chapters of the *management regulations* that are directed to themes of safety management. From one perspective, it can be interpreted that a majority of the sections include themes relevant for safety management. Again, examples of sections from relevant chapters are presented in excerpt. There are four themes in the management regulations that we consider as important in relation to safety management. Here we will highlight the encouragement of individuals and the organization to contribute to safety management.

3. Safety barriers are important to safety management

Chapter I: RISK MANAGEMENT
Section 1: Risk reduction

In addition to section 9 (above)… In addition barriers shall be established which a) reduce the probability that any such failures and situations of hazard and accident will develop further, b) limit possible harm and nuisance. Where more than one barrier is required, there shall be sufficient independence between the barriers…

Safety management implies the establishment of safety barriers. If more than one barrier is needed there must be established a sufficient degree of independence between barriers.

4. Important elements of safety management

Chapter II: MANAGEMENT ELEMENTS
Section 3: Management of health, environment and safety
(cf. Section 13 of the Framework Regulations on the duty to establish, follow up and further develop a management system)
…Responsibility and authority shall be unambiguously defined at all times. The necessary steering documents shall be prepared, and the necessary reporting lines shall be established.

Section 4: Objectives and strategies
The party responsible shall stipulate and further develop objectives and strategies in order to improve health, environment and safety…, …The objectives shall be expressed in such way as to make it possible to assess to what degree objectives have been achieved.

Section 7: Monitoring parameters and indicators
The party responsible shall establish monitoring parameters within his areas of activity in order to monitor matters of significance to health, environment and safety, including the degree of achieving objectives…
…The operator or the one responsible for the operation of a facility, shall establish indicators to monitor changes and trends in major accident risk.

Section 8: Basis and criteria for decision
…decision criteria shall be based on the stipulated objectives, strategies and requirements relating to health, environment and safety and shall be available prior to decisions being made. Necessary co-ordination of decisions shall be ensured at the various levels and in the various areas in order to avoid unintentional effects.
Prerequisites that form the basis for a decision, shall be expressed so that they can be followed up.

Steering, decisions, and feedback are important elements of safety management. Safety management is dependent on clear and unambiguous definitions and possibility to assess results according to objectives. The establishment of safety indicators is necessary for safety monitoring. Decision-making shall be well defined in relation to objectives including decision criteria and coordination of decisions.

5. Competence is important for safety management

Chapter III: RESOURCES AND PROCESSES
Section 11: Manning and competence
(cf. the Framework Regulations Section 10 on organisation and competence.)
… There shall be set minimum requirements to manning and competence in respect of functions
a) where mistakes may have serious consequences in relation to health, environment and safety,
b) which shall reduce the probability of failures and situations of hazard and accident developing further, cf. Section 1 on risk reduction and Section 10 on work processes.
In the manning of the various work tasks it shall be ensured that the personnel is not assigned tasks that are incompatible with each other.
The prerequisites that form the basis for the defined manning and competence, shall be followed up. When changes in manning take place, possible consequences for health, environment and safety shall be reviewed.

Safety management requires an assurance that manning and the competence of personnel correspond to the demands of the activities.

6. Safety management is partly a process of safety improvement that is dependent on feedback

> *Chapter V: MEASURING, FOLLOW-UP AND IMPROVEMENT*
> *Section 22: Improvement*
> The party responsible shall continually improve health, environment and safety by identifying the processes, activities and products that need improvement, and implement necessary improvement measures. The measures shall be followed up and their effect shall be evaluated.
> The individual person shall be stimulated to take active part in identifying weaknesses and suggest solutions, cf. the Framework Regulations Section 11 on sound health, environment and safety culture. Provision shall be made for using knowledge gained through experience from own activities as well as the activities of others in the improvement efforts.

Improvement of safety is part of the safety management, and measuring and follow-up can be viewed as important means for feedback in this process. Individuals shall be encouraged to take part in the process. All excerpts above are collected from the management regulations (2003:5c).

4.3.5.4 Summing up: Regulations and safety management

The NPD framework- and management regulations express several themes that are relevant for safety management. In this respect, the regulations emphasizes not only technological of safety management, but organizational and individual factors. We get the impression that safety management matters each and every one involved in petroleum activities not only managers. Individuals should be encouraged to active participation in the process of safety development, maintenance, and improvement. It seems as if promotion to individual participation in the safety process is one important part of the NPD safety strategies.

It was noted that the regulations reflected several themes of positive safety management. However, we could not see that the regulations did reflect any aspect of the management of NPD's own safety.

4.3.6 Threats identified by NPD

Offshore petroleum activities involve risks from various perspectives, among them personal, technological, and environmental. (fire, pollution of the air and the seas, diving, vessels, helicopters , weather, wind and climate, etc.)

A public NPD document that explicitly identifies internal or external threats to the own organization was not found in the documents analyzed. Instead there are documents that clearly describe projects directed towards safety improvements of various kinds in actors on the NCS. The other way around, if there are documents in which NPD actively focuses planned or recently started safety projects, the safety problems related to the projects are, if not urgent, so at least important. One such document is the NPD annual report 2002 (2003:6). The concerns about a future scenario including declining production rate and exploration are highlighted in the annual report. "Incidents which the regulations require to be reported immediately to the NPD remained at roughly the same level in 2002 as in the year before" (2003:6). Some incidents had not changed in proportion since the preceding year such as falling objects, which continued to represent the largest single category. We will not focus on these aspects of risk. Instead, we will analyze a selection of safety related threats with a more urgent character, and how they are managed by NPD.

In the annual report NPD highlights the needs to take care of a number of identified safety threats. Two lethal accidents shadowed the passed HSE year which otherwise showed no strong changes in any direction.

"One of the fatal accidents falling under the NPD's regulatory authority occurred on the mobile unit Byford Dolphin on 17 April, where the victim was hit by a falling object. The other took place on Gyda on 1 November, when a man was crushed between two containers during a lifting operation. The immediate causes of these accidents have been clarified, but the NPD felt it was important to identify the deeper reasons and has done much work on these. Its findings have been conveyed to the players concerned" (2003:6).

Almost every threat presented is an internal threat identified in companies. No threat (internal or external) is explicitly expressed as one identified in or directed towards NPD. Table 4.3.6 shows a selection of identified safety threats and considered actions to manage the threats.

Table 4.3.6: Safety threats identified by NPD and actions to manage the threats, cited from NPS's annual report 2002 (NPD, 2003:6).

Identified safety threats	**Descriptions**	**Actions**
Use of overtime	-Experience shows that illegal overtime working can only be combated when all sides collaborate and are actively opposed to such breaches -Attention strengthened by the Byford Dolphin accident	NPD devoted greater resources to making checks on working hours from the beginning of the year, partly in response to a number of union requests.
Spurious injury statistics	The number of personal injury cases declined significantly from earlier years in 20021. However, the figures may not be directly comparable. This is because checks on personal injury reporting reveal that some companies have changed the criteria governing which injuries are reported	The NPD believes that these criteria fail to accord with the regulations, and is considering various follow-up measures.
Gas leaks	The number of gas leaks exceeding 0.1 kilogram per second increased in 2002 from the year before2.	Greater attention will accordingly be paid to this problem by the NPD in 2003, in part through more independent investigations of major leaks.
Accidents and near misses related to crane and lifting operations	Special attention was paid to the safety of crane and lifting operations. A number of serious accidents and near misses in this area indicate a need for improvement.	That supposition was confirmed by the checks carried out, and will accordingly be followed up.
Culture	Unfortunately, both supervision and accident investigations have revealed that the HSE culture is not	The NPD is currently pursuing a three-year programme aimed at defining a good HSE culture and analysing the

	always what it should be. The need for change appears to be exist at every level, from boardroom to shop floor.	factors which influence it. The new regulations address an expectation that the industry will now achieve a cultural boost to counter the negative trend of recent years. Challenging established attitudes and developing a new and more integrated understanding of reality are the aims.

4.3.6.1 Summing up: Threats identified by the NPD

NPD identifies several threats as urgent and actions to encounter the threats. The threats are discussed against a background of recent incidents, among them the tragic accidents at Byford Dolphin and Gyda, which give additional impetus to countermeasures. The threats in companies are of various kinds and include both organizational and cultural aspects. However, one situation that ought to be considered as an external threat directed towards the Norwegian Petroleum Directorate are the indications of declining petroleum production over the coming years. Norwegian petroleum incomes are linked to the directorate's own budget, and decreasing gains will probably affect the conditions for the regulatory work. A couple of scenarios, partly directed towards decreasing incomes and the consequences of reduced GNP, resulting from different resource management is identified.

4.3.7 Management of information

The ability of the organizational system to maintain a steady state is partly dependent on the management of information. Participants' apperception about the speed and accessibility of information, the direction of information flow, and arrangements to discriminate between more and less relevant information are all part of keeping the system on an even keel. The management of information is one of several missions in the creation of a positive safety management.

We will first focus on how information management is treated in the regulations. Regulations for information can, for example, be found both in the framework regulations and in the management regulations. Some examples of sections from relevant chapters are presented in excerpt below (indicated by dots preceding or ending the particular excerpt). This time we will not summarize the regulations in connection to the regulatory text, but in the end of this section.

4.3.7.1 The framework regulations

Chapter IV: MANAGEMENT OF THE PETROLEUM ACTIVITIES
Section 16: Use of the Norwegian language
The Norwegian language shall be used in the petroleum activities to the maximum extent possible. Other languages may be used if this is necessary or reasonable in order to carry out the petroleum activities, and provided it does not compromise safety.

Chapter IV MATERIAL AND INFORMATION
Section 17: General requirements to material and information
Material and information which is necessary to ensure and to document that the petroleum activities are planned and carried out in a safe and prudent manner shall be prepared and retained. Such

> material and such information shall be available in Norway free of charge to the authorities mentioned in these regulations Section 55 on supervisory authorities…

Excerpts above are collected from the framework regulations (2003:5b).

4.3.7.2 The management regulations

> *Chapter III: RESOURCES AND PROCESSES*
> *Section 16: Information*
> The party responsible shall identify the information which is necessary to enable planning and conduct of the petroleum activities and to improve health, environment and safety. It shall be ensured that the necessary information is acquired, processed and disseminated to relevant users at the right time. Information and communication systems which satisfy the need for acquisition, processing and dissemination of data and information, shall be established.

The excerpt above is collected from the management regulations (2003:5c).

4.3.7.3 Information on the website

The rules and regulations are available on the NPD internet pages only, according to a “paperless principle” (papirløst forhold). The NPD website is a good example of efforts making most public documentation on Norwegian petroleum activities freely available! The website is found at: http://www.npd.no. The homepage (index) is focused around the latest news, and clearly structured headlines direct the reader to hyperlinks covering various aspects of NPD activities. Examples of information available is: As far as we can see, the NPD site is an example of good web design delivering information both to the public and to actors on the Norwegian petroleum arena. See Appendix 1 for an overview of the channel structure on the NPD's website and headlines of available information.

The information is available in appropriate formats. Except the usual html format, the various NPD publications are available downloadable in PDF format. NPD is also responsible for the production and publication of the bibliographic database OIL covering petroleum literature of Nordic origin. All of the references in Oljeindeks/Oil Index from 1974 until today are to be found in the literature reference database OIL which covers approx. 60.000 references, some also including links to the full text documents. OIL is accessible from the NPD site (NPD, 2003:7).

One convenient solution that makes communication easier is the accessibility to important forms used in communication between NPD and the companies. Today, just some of the forms used for reporting to the NPD are published on the site. The plan is to extend this list (NPD, 2003:8). The forms include:

- Prequalification of new companies on the Norwegian continental shelf
- Reporting of manned underwater operation
- Quarterly reporting of hours worked on installations
- Reporting of damage on load bearing structures
- Confirmation of alert/report about situation of hazard and accident
- Prognosis and results for exploration wells
- Registration of wells

The incident report form "Confirmation of alert/report about situation of hazard and accident" is an important instrument for communication and feedback and is available in Appendix 2.

4.3.7.4 Information management is integrated in the organizational structure

Another important aspect of safety management to what degree the information system is integrated in the organization. As presented in previous chapters information management is integrated as one of three product areas in the NPD organizational structure. The product area of *Data, information and knowledge management* takes a national responsibility to provide petroleum sector data to the NPD partners and to the public. They also develop, integrate and distribute knowledge from the petroleum industry (NPD, 2003:2). In the creation of an organizational model for NPD's activities in which information management include one third of the areait could assume that NPD considers information management to be a very serious matter.However, as with the other product areas, the information available gives no details about how the work is organized in the "multidisciplinary and collaborating teams organized around priority products" (NPD, 2003:2).

4.3.7.5 Summing up: Management of information

NPD has invested great efforts in becoming a state of the art information manager. We have identified several indicators for positive management of information in NPD.

From the perspective of regulations, both framework- and management regulations identifies important aspects of information management. Such aspects relates to: (a) the use of Norwegian as a common language of communication in the petroleum activities, (b) the availability to all safety related documentation of how petroleum activities are carried out, and (c) the identification and use of necessary information to carry out safe operations in petroleum activities, and the establishment of information and communication systems.

NPD has a high degree of public accessibility to documentation of various kinds at their website. The NPD has taken several steps towards a "paper free" solution of information management, and many documents are today only available in a electronic format at the NPD website.

Finally, NPD has integrated information management as one of three product areas in their new organizational model. In doing this, NPD emphasizes the importance and seriousness of information as part of the organizational system.

From our point of view system structures for information feedback are existing and emphasized in the NPD organization.

4.4 Discussion

The study has presented basically four themes of safety management in the Norwegian Petroleum Directorate. A systems perspective was applied in to the themes in appropriate cases. The themes related to the organization in which the structure of the NPD organization was disseminated and modeled from a system perspective. The framework and management regulations were analyzed for content related to safety management. Urgent threats and their remedial actions explicitly expressed by NPD were reviewed. Finally the NPD information management was focused both from a safety management and systems perspective.

4.4.1 The Norwegian Petroleum Directorate: regulation and safety

The NPD's safety strategies become expressed in many of the documents that were analyzed. For example in the regulations, many of them explicitly express a direction toward health, environment, and safety. However, the safety concern is directed towards the licensee only. Safety management of the own organization and the own activities are not discussed in the documents that were analyzed. Examples of this will be discussed below.

4.4.2 The structure of NPD

The boundaries of the suprasystem analyzed, are "the sum of petroleum activities on NCS". First, the Norwegian states petroleum activities (including NPD) presented in documents from MPE, did include both structures and processes representative for a systems approach. Second, the information in NPD documents was too superficial for any deeper analyses of NPD substructures. However, the documents gave more information about system processes in interactions between NPD and other subsystems. We can conclude that both MPE and NPD emphasizes an approach to their activities that allow a systems application on the analyses, but the available NPD documents was not useful for structural analysis of the NPD subsystem. In particular, there was a lack of information about how the teams are organized, how the interaction works within or between substructures, and how boundaries for management are organized at different levels within NPD.

One question raised, was concerning how collaborative groups consisting of members from different subsystems shall be treated in a systems model. Are they structures (however more temporal in character) or processes? This will be treated in coming contributions of this project.

The service declarations together with the regulations tell us what can be expected in an interaction with NPD. Accordingly, these documents are illustrative for systems processes.

4.4.3 Threats to safety

There are numerous threats to safety in offshore petroleum operations. We have focused a number of threats that NPD have prepared actions against. Among the various types of threats we want to note that some are identified as organizational and cultural in their characters. As with the regulations discussed above, NPD did not express any threats inherent in or directed towards the own organization. Only internal threats in licensees were identified.

4.4.4 Information management and feedback

The Norwegian petroleum activities are located offshore, remote from direct physical availability, and located all along the Norwegian Continental Shelf, a vast distance. From this perspective it is easy to grasp the need for good information systems.

NPD shows up many aspects of positive information management. We have focused on three aspects, namely, that the need for good information management is expressed in the regulations, accessibility to much information on the NPD website, including important forms for communication between licensees and NPD, and finally, the fact that information management is identifiable as one third of the new NPD organization. The last fact shows that NPD wants to show how seriously they consider the importance of information management.

Accordingly, there do exist information feedback systems. In addition NPD regulations on that matter emphasizes management of information in several ways.

One fact that relates to information management in general and to safety management in particular, is the NPD emphasizes that organizations and individuals shall be encouraged to participate in safety activities. This is a positive sign for safety management in the way that it may create trust between licensees and NPD. In the long run it may create organizations with safety ideals more internalized in the own organization.

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4.6 Abbreviations

HES	Health, Environment and Safety
MPE	Ministry of Petroleum and Energy
NBH	Norwegian Board of Health
NCS	Norwegian Continental Shelf
NPD	Norwegian Petroleum Directorate
PDO	Plans for Development and Operation
PIO	Plans for Installation and Operation
SDFI	State's Direct Financial Interest

4.7 Appendixes

Appendix 1.

Overview of the channel structure on the NPD's website 20.3.2003

Link: Site map

- Rules and regulations (direct link)
- Fact-pages (direct link)
- English
- Search (with search field)

Topical

- News
- Public case register
- Press releases
- NPD calendar
- Vacant positions

Subjects

- Resource management
  - Exploration
  - Development and operations
  - Resource accounts and analysis
  - Cessation
- Health, environment and safety
  - Safety
  - Working environment
  - Supervision and advice
  - Trends in risk levels on the shelf
- The external environment
- Geographical areas
  - The North Sea
  - The Norwegian Sea
  - The Barents Sea

Products and services

- Rules and regulations
- Facts and statistics

- Geological/geophysical data
- Forms
- Publications
    - The Norwegian Petroleum Diary
    - NPD Annual Report
    - Petroleum resources
    - Continental shelf publications
- The reference database OIL

About the NPD

- Contact the NPD
    - Whom to contact
    - Library
    - Employees
    - Management
    - Subscriptions
- The NPD organization
    - Objectives and duties
    - History
    - Organization
    - Annual Report 2001
    - Service declarations
- Collaboration projects
- International cooperation
- Useful
    - ABC of oil
    - Site map
    - Useful links

Appendix 2.

Confirmation of alert/report to NPD about situation of hazard and accident

NPD

Telefax: 51 55 15 71 or **e-mail: Varsling@npd.no**

The incident occurred: *Date* *Time* *Operator/responsible*	*Field* *Installation*	*Reporting person:* *Name/unit* *Telephone* *E-mail*

Confirmation of alert/report according to the Information Duty Regulation, Sct. 11:	☐ *Sct. 11, 1st paragraph: Acute or serious situation of hazard and accident*	☐ *Sct. 11, 2nd paragraph: Situations that under insignificantly altered circumstances might have led to situations of hazard and accident*	☐ *Sct. 11, 3rd paragraph: Situations of less severe or acute character*
	Brief description		
a) Severe or acute harm or injury			
b) Acute life-threatening illness			
c) Severe impairment or loss of safety functions and barriers endangering the integrity of the facility			
d) Acute pollution: Type and estimated volume to be stated in the description space below			

Supplementary information:

☐ *Transportation*
☐ *Blow-out*
☐ *Explosion*
☐ *Fire*
☐ *Unintentional HC emission*
☐ *Radioactive source*
☐ *Evacuation of installation*
☐ *Cessation of hazardous work*
☐ *Falling object*
☐ *Collision*
☐ *Object/vessel on collision course*
☐ *Hygiene or health related matters*
☐ *Other*

Description of the incident/near-miss:

Additional information:

Emergency preparedness organization activated: ☐ *Y* ☐ *N*
Production/activity shut-down ☐ *Y* ☐ *N*
Number of injured or fatalities:
Extent of the investigation:
Area closed and evidence secured: ☐ *Y* ☐ *N*
NOFO mobilized: ☐ *Y* ☐ *N*
Other measures taken:

Other institutions notified:

☐ *Main rescue service*
☐ *Radiation Protection Authority*
☐ *Police*
☐ *Maritime Directorate*
☐ *Civil Aviation Authority*
☐ *Others:*

5. Safety management of a car manufacturer

5.1 Introduction

From an organizational system perspective, high quality external and internal feedback are essential for successful safety management. The present section will focus on the output of an organization, that of an automobile manufacturer. Thus, the following will treat the safety of the car, that is, the safety of drivers, passengers and other people who may be exposed to the risks.

The threats to people in road traffic are very well known, single car driving off the road, collision from behind, at a left turn etc. The consequences are also well known in terms of fatal accidents, severely injured persons etc. Many of the contributing factors are also known, such as, high speed, drunk driving, night driving etc.

In a similar way the threats, consequences and contributing factors are also known in the nuclear power field. However, some of the knowledge in the nuclear field is more theoretical than the robust large-scale empirical foundation of knowledge about traffic safety. It is clear that when Volvo develops and maintains its safety management process, it is natural to create a system with emphasis on external and internal feedback using many kinds of information that is relevant for safety.

To delimit the scope of the present case study, safety management will refer only to the risk of the product, the car, when it is in planning, production and usage phases. Safety management is a process in which a producer, societal representatives and the public interact in finding a balance between the benefits, costs and risk of a product an activity or process. The goal should be to find a balance, which is the best for most of the people in the society and at least acceptable for everybody. The present paper will illustrate that such a goal can only be reached in a process in which all three parties are actively engaged. In particular, the importance of strong public and societal participation for high quality safety management will be stressed in the present study which, however, focuses on the producer of regular use and not to other risks such as those arising from the manufacturing process or an nuclear power plant. The safety management of the Volvo car manufacturer, which is chosen as an example, should be seen in the wider perspective illustrating some of the issues, difficulties, successes and pitfalls of safety management in general. In particular, it focuses on the management processes for detecting hazards and for feeding information and incentives through the system (cf. Kasperson 1977, who discussed the hazard management process in different areas.)

5.2 The system in context: Society and the car

Few technological inventions have affected human societies as drastically as the automobile. The introduction of cars quickly changed he space and time patterns of human living. The car also became one of the economically most important products of an industrialized society reflecting both the benefits it brings and its costly side effects of accidents and pollution. In the US alone, motor vehicles now cause about 40-50 000 deaths and 4 million injuries each year (Haddon and Baker 1979; Faigin 1977; Bick and

Hohenemser 1979). The economic resources allocated to prevent, mitigate and pay for the consequences of the accidents are large.

Before analyzing the way in which one manufacturer deals with the risk created by the cars it produces, it seems valuable to consider the societal safety management authorities that constrain its actions. In the USA there are government regulations effective in the whole nation but also regulations valid only in some states, such as the California standards for emissions. On the federal level, the national car safety and the Environmental Protection Agency (EPA) for emissions. In addition, the Federal Trade Commission (FTC) is responsible for warranties and NHTSA for safety recalls and fuel economy, and EPA for emission recalls. A recall mean that the company retrieves the car and pays for the repair or replacement of a defective component or system, and this process will be described in more detail later in the paper. If the defective component is safety-related the recall is regulated by law. Fuel economy is related to emissions, and concerns not only NHTSA but also EPA. Through the Federal register notices of proposed rulemaking, NHTSA communicates the standards it plans to implement in the future. Recently, US automobile regulation was set in an international perspective in a very comprehensive study (Hill, Priest, Heaton, Hanrahan, Harrison and Andrews, 1980; Maxwell, Heaton, McCleary-Jones, Priest, Hill and Harrison, 1980).

In Sweden, the National Swedish Road Office (Vägverket) and The Swedish Environment Protection Board (Naturvårdsverket) share the main responsibility for automobile standards. The Swedish motor Vehicle Inspection Company (AB Svensk bilprovning) plays an important role in carrying out all official vehicle inspections in Sweden but it is not responsible for any regulations. In a historical perspective, the contacts between the Swedish automobile manufacturers (Volvo and Saab) and the Road Safety Office differ somewhat in that larger Volvo manufacturer seems to have more informal contacts with the office. The largest car manufacturer in the country tends to get a leading position not only formally, but also informally. These contacts are not the only ones for discussions between the industry and the society as the industry is also represented in societal committees treating traffic problems.

5.2.1 Compliance with Regulations

There are two generic ways to ensure that a new car fulfills the requirements of technical regulations set up by the agencies, namely, *self-certification* and *type approval*. Self -certification is performed by the manufacturer, who certifies that the car model produced fulfills applicable legal requirements. *Compliance control* is sometimes performed by the authorities as a check of the self-certification procedure. Type approval is given by the state agency carrying out the official vehicle inspections. Typically, one vehicle out of a series of identical vehicles is thoroughly examined and granted a type approval valid for the whole series. In passing, it is interesting to note that EPA certification is a combination of self-certification and type approval. In addition to investigations of new vehicles, some countries perform *annual vehicle inspections* of older cars checking deterioration due to time, use and damage of safety related details of the car.
In addition to the rules followed in self-certification, type approval and annual inspection routines, *product liability* is a legal concept or doctrine which determines the rules according to which a manufacturer is held liable to pay damage for injuries caused by a defective design or manufacture of a product. This legal doctrine is very important

for the technical safety of cars. Under the *strict liability doctrine*, particularly in USA, the privity rule has been essentially abandoned, which means that the injured party can seek relief in the court directly from the product manufacturer. In doing so, the injured party does not have to prove the defendant's negligence but only to show that he or she was "unreasonably" injured by the defendant's product. This gives the consumer a strong position and it requires a reputable manufacturer to establish special product liability prevention measures to enhance his posture. The product liability laws constitute one of the strongest incentives for hazard management in an automobile manufacturing company.

The Swedish Road Office is responsible for regulations concerning automobiles and coordinates efforts to improve road safety in Sweden. The annual safety inspections of all cars two years or older are carried out by the Swedish Motor Vehicle Inspections Company employing guidelines issued by the office. Proposals concerning changes in legislation are formally or informally affected by initiatives from, e.g., The Vehicle Inspection Company, the car manufacturing industry, insurance companies, international laws and requirements, the courts, the media and political forces. The Inspections Company is quite active in suggesting regulations, which should be formulated and interpreted by the Road Safety Office. The Swedish Motor Vehicle Inspection Company is responsible for what is now called *type inspection* (Öhn, 1979). Already in 1963, the Swedish Parliament decided to introduce *periodic annual vehicle inspection* for all registered motor vehicle and trailers. A company, the Inspection Company, was formed and the inspections started in 1965. The Inspection Company is financed by inspection fees exclusively (on a nonprofit basis). The inspection concerns safety-related functions of the car of technical nature, including exhaust emission tests (smoke density for diesel engines and idle CO-check for gasoline engines). The inspection program is designed to enable the discovery of defects of safety-related details which can be assessed by simple checks. The inspection results in an inspection report which is given to the owner after the inspection and contains information about how to correct any defects and whether the repair itself must be inspected. In 1974, formal rules were issued by the government concerning all national testing and inspecting activities. Instead of having different agencies testing different aspects of the same functional unit (e.g., the car) only one organization was designated responsible for one specific product; in the case of cars, The Motor Vehicle Inspection Company. This was an important improvement.

The inspection statistics are published annually. The raw material for the statistical reports consists of inspection report copies filed at the company's head office. Any automobile manufacturer or general sales agent, who whishes to get more information that is contained in the statistical reports, can have access to the raw material. There seems to be no comparable reservoir of so detailed and complete information in any other country.

5.3 Safety management philosophy and system approach

The first Volvo was produced in 1927 and during the years around 1930 only a couple of hundred cars were made each year. In 1928 the first Volvos were exported and since then the export market has become the company's most important market. Today, Volvo is an industrial group manufacturing many products. The Volvo group of companies is Sweden's leading exporter and it's product's represent about one tenth of

Sweden's total exports. The Volvo Car Corporation has been profitable through all the years (except for a small loss in 1980). It has now been sold to Ford, but the Volvo group still produces trucks and all their other products as before. The Following analysis is based on Volvo the car company of 1980 and is interesting as a case study with generic implications.

The companies belonging to the Volvo group produced about 300 000 cars mainly in Sweden, Canada, Belgium and The Netherlands in 1981 of which some 170 000 were built in Sweden. The cars produced in The Netherlands belonged to the smaller car series whereas those produced elsewhere are 1300 kg cars of the 240/260 series, which will be the car in focus in the present paper.

5.3.1 Safety Management Philosophy of Volvo

When Volvo manufactured cars in the thirties and forties the road were bad and the climate was (and still is) harsh in Sweden, which made it necessary to build strong high quality robust cars. Early quality requirements of importance for the safety of the cars were, e.g., laminated windshields introduced in the thirties: and later windshield defrosters. Quality and safety were and still are closely related concepts in Volvo and safety is regarded to be one of the aspects of quality. In the sixties safety became an important characteristic in itself which was considered effective in marketing Volvo cars. In the seventies safety was the most important aspect of the cars. In the early eighties reliability became the top priority followed by safety in the internal hierarchy of goals to be met by the manufacturing process. This may be seen as an example of a company's aspiration level having been reached (cf. Siegel, 1957: Simon, 1959, Cyert and March, 1963) or as a market adjustment (this change matches the results of Volvo market research).

During the late fifties the safety profile became more clear when padded dashboards and seat belts were introduced in all Volvo cars. Why safety became such a salient feature for people of the Volvo company we do not know for sure. Perhaps the Scandinavia mentality of careful planning and regulation which may be illustrated by the fact that as early as 1906, when there were very few cars in Sweden, every owner of an automobile was required to have it inspected to get a certificate indicating that the car conformed to the official requirements at the time (cf. Öhn, 1979, who gives a historical introduction to safety in Sweden and Bick, Hohenemser and Kates, 1979 for the US scene). Following this, the still very small but increasing number of cars was taken as a reason for the introduction of type approval inspection already in 1930. This can be compared with USA where cars were much more common and Congress passed it's first highway safety legislation not earlier than in 1935 authorizing the Interstate Commerce Commission to establish an enforce safety standards (Bick, Hohenemser and Kates, 1979).

Perhaps, the fact that the general manager (Engellau) was convinced about the importance of safety was crucial in forming Volvo's early safety profile. Perhaps, Mrs Engellau who was a physical therapist informed her husband and other Volvo people about the consequences of an accident in a very efficient way. These and other speculations come to one's mind when studying a company that so successfully sold cars on the basis of safety when others didn’t, even when this led to devoting a whole section of their sales brochures to illustrating what happens in a collision. An interesting comparison is Ford's unsuccessful attempt to sell safety in the fifties. In 1980, Volvo's informal reaction to attempt was that Ford's attempt was a one-shot, one-component effort founded on a shallow safety philosophy.

5.3.2 Systems Approach to Hazards

The following was based on the conditions in 1980, but Volvo still has a systems approach to the problem of hazards associated with the car. In 1966 the United States enacted companion legislation entitled the Highway Safety Act and the National Traffic and Motor Vehicle Safety Act. Both acts relied on issues of standards based on a systems approach which is adopted by Volvo. These acts were important for the management approach to safety implemented in Volvo in the late sixties. The Volvo systems approach was explicitly formulated by the head of the Safety and Environment Department, Luritz Solberg Larsen (1975, p. 42 ff). To summarize, Volvo designers consider possibilities for reducing injuries by improvements made in pre-crash, crash, or post-crash safety (cf. Haddon 1972). In the following, designing a car to avoid accidents is called *crash avoidance engineering*. If an accident happens, its consequences may be mitigated if the compartment is strong, the deformation zone of the car sufficient and through other design efforts. Designing a car to protect people from the consequences of an accident is called *crash worthiness engineering*. Immediately after an accident it is important to be able to get people who may have been injured out of the car quickly and safely. For instance, the car should not catch fire or be deformed so that the doors cannot be opened if an accident should happen. Designing a car for this purpose is called *post-crash engineering*. The system approach adopted by Volvo includes creation of feedback systems for identification and correction of road and vehicle hazards.

The organization of Volvo Car Corporation in 1980 indicated that quality and safety aspects of the cars were handled in many parts of the organization. However, the coordinating unit for safety and environment belonged to the *Department of Quality*. The crash worthiness and crash avoidance investigation were performed in Volvo Safety Center which belonged to the *Department of Product Development and Design*. No single specific organizational body was devoted exclusively to hazards management.

5.3.3 Safety and Environment Department in 1980

Generally speaking, this unit is responsible for developing the Volvo policy and organization to conform to legal requirements regarding safety of the cars (e.g., engineering requirements and product liability laws). The unit represents the company in contacts with national agencies concerning safety questions of the Volvo cars produced. For instance, legal and type approval requirements in different parts of the world are collected, the information analyzed and distributed through a formal routine to all relevant units i Volvo. Furthermore, the Safety Environment Department is responsible for compiling technical specifications needed in product liability claims and for Volvo’s presentation of that evidence in case of a court trial. That is, the routines for product liability claims are closely connected to the Department which also represents the company when arranging for type approval and type certification of cars. The Quality Department publishes the Volvo routines for ensuring that the manufactured cars comply with legal requirements and the results of these control routines. A very important instrument is the Legal Requirements Design manual which is issued by the Safety and Environment Department and provides all necessary information about existing laws and technological specifications from the whole world.

Within Volvo, the Safety and Environment Department is responsible for establishing and maintaining the required posture for product liability and for coordinating the overall product liability prevention and reduction program. To exemplify, the preventative activities consist of the following programs: (a) total quality assurance including vendor quality control, (b) design review programs, (c) special marking and handling programs for safety and emission systems and components, (d) legal requirements tests, and (e) individual reporting responsibility for product defects delegated to the lowest echelon. Furthermore, restorative activities include rapid retrieval of documentation pertaining to different units within the Volvo organization, service network corrections and fast repair when required, and competent engineering representation in legal proceedings etc. Environmental protection involves emissions and fuel economy, noise and scrapping with material reuse.
The Safety and Environment Department comprised about 15 persons in 1980 and the formalized communications in the group were kept to a minimum so the work would flow with as little bureaucracy as possible. Since the early seventies the Department increased gradually with a clear support from the Volvo management. In 1980 the approximate preferred size seemed to have been reached, This coincides with the above-mentioned change of internal top priority goal from safety to reliability of cars. Typically, the people working in the Department are nearly middle-age persons (although one man had worked for Volvo since 1929!) and they tend to stay in the Department to the benefit of continuity. Most of them are technicians and one has a degree in law. The staff is working with many informal contacts in parallel with the information distributed formally through the company.

5.3.4 The car manufacturer securing feedback about the safety of its product

5.3.4.1 The Volvo Safety Center in 1980

While the Safety and Environment Department mainly analyzed information in documents, reports and journals, the Volvo Safety Center also generates a great deal of research and development data. The work of the center includes crashworthiness tests and accident investigations. About 30 people work in this unit and they work in close connection with the designers of the cars.

5.3.4.2 Crash Avoidance Engineering

The Volvo Experimental Safety Car (VESC) was exhibited during the Third International Conference on Experimental Safety Vehicles in Washington in 1972. Since then it was developed continually and safety components and systems incorporated in the cars in production from 1973 and on. The very existence of a *safety target* was probably very important for the engineers in Volvo. To exemplify, one of the characteristics required from VESC was that its handling characteristics should change as little as possible especially in different emergency situations. Thus, the car should permit a large percentile if the drivers to form a man-machine system which is controllable in critical situations (cf. Jaksch, Gustavsson and Solberg Larsen 1974). Measuring the handling characteristics of a driver-vehicle system has been a great difficulty for car inspection agencies and auto manufacturers alike. A summary of work in this field is provided by the reports by Jaksch (1979a, b).

5.3.4.3 Crashworthiness and Post -Crash Engineering

According to Åsberg, Larsen and Runberger (1976) "Volvo's approach to the design of a vehicle with a given crashworthiness is basically empirical. In addition to this, simple calculations are performed on various sheet metal configurations to judge, on primary level, the elastic behavior of the structures" (1976, p. 476). As a measure of Volvo's investment in designing crashworthy cars, each year about 70 full scale tests (of prototypes, test cars and regular cars from the production line) are made in the Volvo Safety Center crash track which corresponds to roughly 40 tests per 100 000 cars produced. Several hundred additional tests are also made on the cabin accelerator in the Safety Center where the design of specific safety details are tested. Recently, the quality of Volvo crashworthiness engineering was tested by NHTSA in a 35 mph frontal barrier crash test in which the outcome was the best recorded so far (Insurance Institute for Highway Safety, 1982) which is an indicator of the effectiveness of Volvo's safety management.

As other researchers in the field, Volvo through the VESC of 1972 found that strong arguments pointed to a design of the 240/260 series with a long deformation zone. Informally, Volvo estimates one of the safety benefits of that design to be about 7 lives saved per 100 000 cars in use. As mentioned above, the existence of safety prototypes in the auto manufacturing industry seems very important for the reduction of hazards. Clearly, other industries (e.g., chemical or energy producing industry) and society should profit from the introduction of the safety prototype idea instead of focusing on official safety standards. As early as in 1959, Volvo began to introduce three-point seat belts as standard equipment in all their models. Following this introduction, Volvo performed a large-scale study of the effects of seat belts on driver and passenger safety which clearly demonstrated increased safety for driver and passengers using their seat belts in comparison with those who did not (Bohlin 1967; Volvo 1967). In fact, the results were available to the US National Highway Safety Bureau in advance of the planned date of publication of the report and apparently had considerable impact in resolving questions regarding the net positive effects of safety belts which, at the time were questioned, by different parties including auto manufacturers and the Federal Highway Administrator. Later, Bohlin (1977) followed up this research and studied the effects of introducing the Swedish law requiring front seat passengers and drivers always to be belted.

5.3.4.4 The Accident Investigation Group in 1980

This group was started in 1965 with the chief aim to gather facts of importance to the product development of new cars. In particular, the investigations considered why drivers and passengers are injured in accidents, the physical limits of human physical tolerance, accident sequence and consequences of accidents in relation to vehicle and driver performance. Since 1970, the accident investigation group makes thorough on the spot investigations of all accidents within one hour's travel by car from the Safety Center (in Göteborg). In all, just over 1000 accident investigations have been performed and filed from the start of the work. However, to the present author's knowledge, no condensed review of the results and findings from all these cases is yet available, although reports covering parts of this rich material are published (e.g., Samuelsson 1973; 1974). In these investigations it is possible to discover facts, which are difficult to simulate. To exemplify, the Volvo steering wheel design was affected by such investigations. Crash tests with dummies did not show the disadvantages with a steering wheel with only two spokes attaching it to the center axis. Now, there are four spokes for a better distribution of the force on the human body in case of a collision. The costs of the accident investigations may be estimated to between half a million and one million $US per year in 1980 (approximation by the present author, cf. Englund 1978).

5.3.4.5 The Recall Committee

According to a 1966 US law, suspected safety-related defects must be reported to the authorities (*defect notification*). If the defect is systematic, the owners must be informed (*owner notification*) and the car is recalled. From December 25, 1974 the car manufacturer must also pay for the repair (recall) of defective vehicles less than 8 years old due to US law. This corresponds to repair of a subsystem in systems terms.

These conditions made it necessary for Volvo to adapt the organization and to form an organizational body handling possible recalls and notifications. The Recall Committee was founded in 1972 by the Quality Department and comprises specialists in quality, design, production, service, spare parts and law. The Committee used to handle about 200 deficiency reports a year, of which about 10 could be judged as potentially serious and deserving further investigation. In the years up to 1980, the numbers of potential cases dropped to less than 100 reports a year and about 10 reports per year were judged as serious. The reduction of the number of potential cases may reflect an awareness of the Committee in the company, which has obviated some of the controls performed by the Committee early in its existence. The information leading to recall comes from several different sources. For example, the service organization may report a suspected defect to the committee. Two or three recalls were made each year up to 1979. In all, a total of about 20 recalls were actually made over the years up to 1980. Volvo made recalls on its own initiative and there was never a legal enforcement.

5.3.4.6 Exemplifying a Safety Management Routine in Volvo

As clear from the earlier text, an automobile manufacturer reacts to societal regulation by creating routines to cope with the societal demands. Two of these routines have been briefly mentioned earlier, *viz.* those for *recall* and *product liability claims*. While these two routines were formed as functional responses to external demands across the organization (cf. Pfeffer and Salancik 1978), the *quality control* process is integrated in the basic organizational structure of Volvo.

5.3.4.7 Quality Control

The quality concept includes aspects such as environmental factors, operating characteristics in different situations, reliability of functions of the car, maintainability, fuel economy etc. Some of the quality aspects are directly related to safety and others more indirectly. Naturally, quality control is applied at all stages within the car manufacturing and maintenance process. Roughly, about on tenth of the total time spent by people on the assembly line manufacturing a car is devoted to quality control. General quality controls performed in order to fulfill specific requirements, which may originate from customers, product specifications, safety requirements etc. Given limited resources, the priority order between attending to different types of quality aspects was the following in Volvo in 1978.

> In setting priority because of limited resources, the resources available shall first be applied to solve safety and legal requirement problems, and next to solve customer irritation problems. The measure aimed at solving problems which initiate high warranty costs are given priority before action to facilitating manufacturing. Sörensson 1978, p.5).

Many of the quality checks are made by subcontractors to Volvo. The suppliers are completed responsibility for the material supplied and that the parts are conforming to the established specifications. Thus, the supplier is required to, by inspection, verify that the product requirements are maintained and to appoint an *identifiable person with total responsibility* for the quality of the products supplied at a given moment. Furthermore, the supplier must compile *a quality handbook*, *keep documentation*, and *retrieval systems* covering the products delivered in those cases where Volvo so specifies.

The quality control process starts by an initial sample testing to verify that the supplier has correctly understood the specifications. In receiving protocols of inspections, Volvo follows up the quality of materials and components. Each component used in a Volvo car is classified in one of four categories in order to allocate quality control resources as effectively as possible. When a component is classified in the category of highest priority it is marked with a particular symbol, which indicates that the quality specification concerns either a regular according to law and/or a safety requirement set by Volvo. (This original Volvo symbol has now become officially approved as "Swedish standard".) This means that the product units *must document* all the critical steps in manufacturing these items (e.g., the producer should document inspection planning, product planning, and material handling). This document is kept on file until 10 years after the quality routines ceases to be applicable. For the other three categories of components very advanced and powerful statistical decision rules are used (cf. Sörensson, undated) and in fact, the quality control routines for non-safety related Volvo details have more statistical power (cf. Cohen 1969) than had the Swedish tests for testing seat belts Pettersson (1976).

5.3.5 Safety management and feedback during the stages of product development

5.3.5.1 Company and Accident Hazard Feedback

In the foregoing presentation of safety management it was clear that this conception of the Volvo organization is insufficient to describe the work that actually takes place in Volvo in 1980. A systems approach to car production and hazard control makes it necessary to form many informal and formal groups (e.g., the Recall Committee) cutting across administrative units to enable responses to internal and external feedback. Some of the internal and most of the external feedbacks, which forced these adjustments of the organization are presented in Figure1. All of Volvo's safety management routine are formal and are created through following organizational routines. However, there is always informal safety lobbying going on in the company and eventually these informal contracts on intermediate levels may result in higher level decisions about hazard management standards and routines. Influences across auto manufacturing companies when they develop their safety management routine are very interesting but difficult to study, because competing companies do not advertise their adoption of another company's routine. Rather, it is the custom not to admit influences from other companies. Therefore it is difficult to determine the impact of Volvo on other companies safety management routine in other than indirect ways (as, for instance, Volkswagen hiring one of the most important creators of the Volvo quality and safety program). There is always a lot of communication between car manufacturers going on in the committees (e.g., CCMC a committee for auto designers organized on a European Common Market basis). So if one company wants to adopt parts of another company's safety management routine this is done in secret after some patient and silent research work for which branch organizations play an important role.

Basically, there are three groups of agents that can prevent or reduce auto hazards: the *individual* or driver (by, e.g., buying a safe car, mounting safety equipment, making manufacturers and promoting active inspection), and the *company,* which can concentrate more intensively on the car component in the driver-vehicle-road-system. The following elaboration on Figure 1 describes Volvo's safety operations from a functional, systems centered perspective. It focuses on the information reaching the company both for feedback that it generates itself and that generated by the two other agents, society and driver. In other words, Figure 5.3.5 depicts the environment in which the organization learns and adapts (cf. Feldman and March 1982).

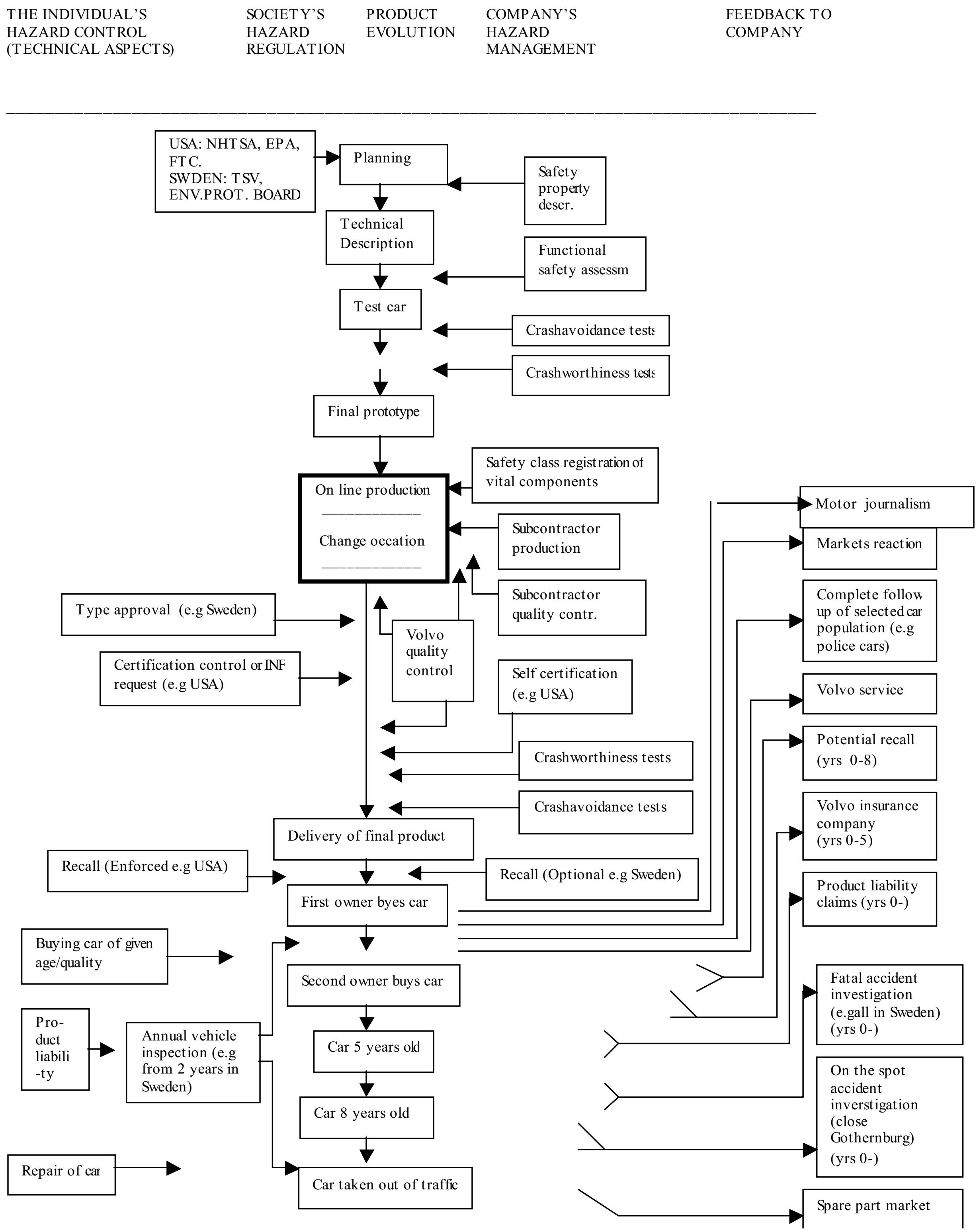

Figure5.3.5: Feedbacks for Volvo Safety Management during Design, Production, Marketing and Use of car.

5.3.5.2 The Planning and Reproduction Process

The change-over to a new car model may start with preliminary ideas as early as 7 to 10 years before mass production can be started. The more intensive planning work may start about 4-6 years ahead of mass production of a new car, change of existing models are planned only 2-3 years ahead. The planning process runs through different stages and is influenced by many people including the members of some committees. In 1980, novel integration effort could be seen in a committee of some ten experts from different administrative units in the Volvo organization each representing a different functional characteristic of the car (e.g., comfort). Thus, crashworthiness is covered by one of the people in the committee, comfort by another one etc. The committee is one of the main bodies for providing feedback during the construction work. The functional safety requirements that it imposes (e.g., crashworthiness) are derived from laws, other regulations, accident analyses, driving and laboratory tests. Although formal analyses are made to weigh costs against safety, consensual views on the costs and value of safety measures are considered. For example, antilock brakes ameliorate the consequences of sudden braking especially on low friction road surface but the costs for such systems exceed $ 1000 per car in 1979. Everybody in Volvo knew that this was considered too expensive for the estimated benefit (estimated to be effective in 4-7.5 % of all automobile accidents, cf. Rundquist 1974). However some 20 years late the costs were reduced and the cars have antilock brakes. The great flexibility in the early planning phases is intended to compensate for the strictness of the rules once cars are in production. For example, all non-safety related changes are deferred until scheduled production changes, usually at the annual model changes-over.

5.3.5.3 Mass Production

As mentioned earlier, an elaborate quality check system has been developed and the safety control work is to a great extent performed locally illustrated in the quality control boxes of Figure 1. When the first cars of a model are finished, type approval or self-certification ensures their safety as well as the company's regular laboratory crashworthiness tests. Crash avoidance tests are also performed with prototypes, test cars and regular cars. The characteristics of the regular cars serve as a base line in producing new prototypes for new models and their crash parameters. All these routines feed information back to managers and technicians active in the reproduction and production phases. Certification or compliance control, the check of the company's routines is made by national authorities to ensure that the company follows the legal requirements in that nation. To, exemplify, officials from abroad may visit the company and inspect the facilities for controlling the safety and the quality routines used by Volvo (e.g., including the full scale crash laboratory). All these routines give feedback of information or penalties of great importance for the safety management of the reproduction and production processes.

5.3.5.4 Car in Use

After a car has been delivered to a customer, safety management changes in character. From mostly an "in house endeavor" where almost all safety requirements have been defined by the company and tested by the company, safety questions must now be treated in interaction with the public, market, and society. Now, the feedback to the company becomes slower and more unreliable; in addition it is affected by other values than the company's. The arrows in the bottom half of Figure 1 show Volvo's different possibilities for getting information about the safety of its cars.

Market Journalism. Reactions from the general press and professional automobile journals both interpret and affect the public and the market. It is certainly worth its own investigation to analyze motor journalism; what topics are favored, how safety-minded are the reporters, and how the public and the car manufacturers are affected by the reports.

Market Reactions. The extent to which market reactions reflect safety is not clear, but the introduction of split brake systems and head restraints may have affected sale volumes for Volvo. As mentioned earlier, Volvo markets it products with safety as an important characteristic and sells its cars to "above average safety-concerned drivers." However, the feedback from the market is probably slow and unreliable from a safety point of view. Customer inventories may be seen as measures of market reaction and are important for the company's aspiration level for safety standards as demonstrated earlier.

Complete Follow up of Cars in Use. Much better feedback comes from the complete follow up of some types of cars (e.g., police cars) in Sweden. Because of special service contracts, as special fleet of about 1000 cars per model year supply feedback, during three years in the form of special repair reports about failures, near failures and repair costs.

Volvo Service. Although most cars are not repaired by Volvo service companies after 5 years, some are followed in detail up to 200 000km through special service contracts with the Volvo field service organization.
Potential Recalls. Information about potential recalls may not lead to a recall but still provide information of value for safety engineering. Recalls have up to recently been optional in Sweden and are enforced in the USA during the first eight years of the car.

Volvo Insurance Company. Volvo is unique in having a long series of detailed information about its cars during the first 5 years because the sales contracts have included free warranty in a Volvo-owned insurance company (Volvia). The company may analyze the costs of increased safety, e.g., the safety improvements obtained by constructing longer deformation zones. However, this type of information cannot be obtained from outside the company. This feedback source seems highly reliable, quick, secret and kept within the company. But, then feedback works reliably only during the car's first five years. After this, many owners do not pay to renew their insurance contracts covering repair costs with the company.

Product Liability Claims. The number of product liability claims is small, so that few quick changes are initiated by them. However, these laws have been very important for creating routines in the preproduction and production process to avoid later costly product liability claims. Product liability laws and claims constitute a feedback resulting in fundamental management and production changes in favor of safety.

Analysis of All Fatal Volvo Accidents. The accident investigation group registers all Volvo accidents in Sweden. If an accident was fatal, the accident is analyzed and the result put on file. Just under 100 such accidents occur in Sweden in a typical year. The feedback is not totally reliable as second-hand information (e.g., police and insurance reports) has to be used in most cases. It is also rather slow but has the advantage of covering the whole length of a car's life.

On the Spot Accident Investigation. Considered as feedback, the Accident analysis Group's reports are direct and provide evidence also about hazardous details not possible to identify in the laboratory. Covering real traffic and analyzed directly, the analyses are of a high quality and validity. Therefore, this feedback, mainly concerned with crash and postcrash information, may have quick and important effects on the preproduction and production processes.

The Spare Part Market. The safety spare part market gives rather slow and unreliable information because so many parts are not manufactured by Volvo. Unfortunately, when the car becomes old and presumably less safe this feedback gets weaker and weaker.

Annual Vehicle Inspection. The annual vehicle inspection (depicted on the left in Figure 1) gives excellent feedback concerning wear of safety related details. It seems to be the only reliable feedback source that works through the whole lifetime of a car. Therefore, it is important for ensuring a high level of technical safety of the vehicle on the roads and at the same time it provides valuable information for the manufacturer. However, as pointed out by Bick, Hohenemser and Kates (1979) the costs-safety-effectiveness of these inspections have been discussed in USA.

5.3.5.5 Comments on the Feedback System

In summary, the information feedback system for accident hazard information to the company must be considered quite elaborate. It is hard to find any product for public consumption that has a comparable feedback system for safety management. For example, the management of the hazards of drugs for medical purpose is much less complete and reliable than the system depicted in Figure 1. Some of the feedback sources in the diagram are more general, including safety aspects (e.g., complete follow up and Volvo insurance company) while others are primarily safety oriented (e.g., fatal accident investigations and annual vehicle inspection). Some of the feedback loops are managed internally by Volvo and are open for external researchers to a greater (e.g., on the spot accident investigations) or less (e.g., insurance data) extent. The information in the external feedback from the annual inspection is public and open to any interested party for further analyses.

Although the accident feedback management process is of a high quality, there is one characteristic, which seems important to comment on, namely that of feedback from *older cars*. From checking all the feedbacks in Figure 1 it is clear that the accident feedback management process of the new car benefit from feedbacks from all the sources but that this is not at all the case for the aging car.

Pollution Control-Feedback Possibilities
Even though the present paper has been focused on safety management to avoid accidents, the hazards of air pollution from cars provide a reference point worth brief comment. As late as 1968 the US Government sued General Motors, Ford Chrysler, American Motors Corporation and the Automobile Manufacturers Association for collusion to eliminate competition in research and development of exhaust emission cleaning devices for motor vehicles and rig the prices of patents related to this equipment. In September 1969 the changes was dropped on condition that there would be no further collusion (Mahdavi 1972). Exhaust emission management is now rapidly

becoming an increasingly important issue, even though the 2003 US government seemingly partly neglects this hazard.. For example, annual benefits from cleaner air following the US Clean Air Act have been estimated to as much as 15-20 billion (1973) US dollars (Smith 1976), with the contribution of reducing automobile exhaust pollutants estimated at 2.5 to 7 billions and up to 15 000 lives saved (US senate Committee on Public Works 1974; see Committee Print of United States Senate, 1980 for an overview of reports, and results). As a concrete result of this state of affairs, Volvo has devoted the lambda sond system for the USA market (initially for California) but this system must be used with lead-free gasoline and cannot be introduced to Sweden. If the feedbacks in Figure 1 are applied on exhaust emission management the following can be said.

Feedback information about exhaust emission control is obtained within the company when testing new engines. Type approval and self-certification give additional information about the success of exhaust emission cleaning for new motors and cars (cf. Figure 1). However, motor journalists seldom write about air pollution (but others do). The car markets sensitivity to air pollution is probably low if the exhaust are not smelling very badly (e.g., two stroke engines). Volvo's complete follow ups of selected car populations and Volvo service could provide excellent information about exhaust emission control but to the present author's knowledge no such reports have been published. Given proper regulation and pubic interest, recalls could be enforced and product liability claims made if exhaust emissions exceed the standards. The Volvo insurance company, the fatal accident investigation, the on the spot accident investigations and the spare part market could give valuable information about exhaust emission control- but none of these sources were tapped at the time. Fortunately, the annual vehicle controls provide an opportunity to test the quality of exhaust emission control but the technical reliability needed in such tests requires better equipment than used today for the analyses. Unfortunately, emission tests used by the Inspection Company at the time must be considered lax and incomplete in Sweden (cf. Stork 1979; see also Lundquist 1980, who describes clean air polities in Sweden). In the beginning of the 1980ies, the Company started registering the CO emission level for each car in the annual inspections. This was an important first step as it gives statistically sound information to the public and the car manufacturers- quantified feedback information that did not exist earlier. Finally, at the time there existed no additional feedback loops for exhaust emission management in society and industry must be considered inefficient in comparison with the accident management process.
Twenty years later, the situation is much improved with strict emission tests as part of the annual inspections.

To summarize, an information feedback system, which could be used for information about exhaust emission cleaning existed at the time. But the information fed into the system seemed scarce. It was argued that, first more knowledge must be compiled about the negative effects of air pollution and in particular the effects on humans from pollution from cars interacting with pollution from other sources. This would lead to an overall more adequate and justifiable standard setting. Such knowledge has become available very rapidly during the last 20 years, e.g., in areas exposed to heavy acid rain (e.g., West Germany). Second, in Sweden the reliability and the scope of the inspection program concerning present and future standards for car in use should be improved and the consequences of violating the standards made perceivable. Third, this would lead to more societal and company interest in safety management including exhaust emissions. Fourth, perceived economic incentives in industry and society are probably necessary for initiating and maintaining more effective exhaust emission hazard management in the field (such as charges varying with degree of pollution).

5.4 Concluding Comments

5.4.1 Safety strategy

The Volvo Car Company considered safety as a pride of the company and its employees and turned it into a means of competition through their own media campaigns. The company of 1980 was an example of a company with quite advanced safety management routines through internal and external feedback to secure the safety of the cars. Great flexibility when designing a car was coupled with strict rigidity when assembling the car. These activities were both in-company processes.

The profit made by the company was sufficient for the owners who were strong with a long term perspective. This gave room for development of safety. There were explicit, concrete and a history of already implemented safety goals. Volvo constructed their own technology with adequate documentation and the technology was modern, adaptive and interesting for those working with it,

5.4.2 Competence

The Volvo car company constructed their own technology with adequate documentation and the technology was modern, adaptive and interesting for those working with it including those who were responsible for safety management. The staff of the company was highly competent in dealing with *subcontractors*. The staff knew as much as the subcontractors and there was a strict system for controlling safety related details and components.

The staff designed *internal and external feedback,* control systems that were cost effective and very strict on safety. Not only the internal feed back loops, but a majority of the external feedback loops were also created by the company itself. Most of these external feedback loops were not imposed by societal regulations. There was a difference in competence between the regulator and regulated and the regulated industry was better informed than the regulator about some issues (e.g., the statistics of spare parts and of the insurance company).

5.4.3 Power and authority

Because of the high priority given to safety and the fact that it was implemented, it was clear to everybody in the organization, that the safety management department had an important say in the company. The Safety and Environment department had added authority to their unit through having won all court cases against Volvo concerning safety cases in the USA.

5.4.4 Integrity

The exact degree to which safety management in the organization was unaffected by influences from other systems was hard to determine. However, the Safety and Environment department did not openly oppose the negative environmental effects of leaded gasoline at the time. This seems to represents some kind of external influence making it reasonable not to insist on eliminating this risk factor in Sweden.

Taking the regulator perspective, the lead of Volvo in most safety issues might have been helpful, but it might also have hampered regulator initiatives. Volvo was one of the biggest export industries in Sweden at the time, a fact that may have an effect also on the political level, which in turn could influence the regulator.

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6. General discussion

6.1 Structure and policy

6.1.1 Organization

In the aviation sector, reorganization of Swedish Civil Aviation Safety Authority (SCASA) had just been carried out and the same was true for the Norwegian Petroleum Directorate (NPD). Some of the resulting uncertainty of who was responsible for what safety issue remained in some parts of SCASA a year after the change. However, there were different views on this in the organization and some employees found a more clear division of responsibility after than before the change.
The NPD gave little information in their open documentation about boundaries of responsibility within the teams created around “priority products”.
Volvo seemed to be reorganizing too, but not as much as the other two agents. The Safety and Environment department had an excellent company record (e.g., winning all court cases against Volvo in the past) and was left largely unchanged at the time, which was constructive for safety management.

6.1.2 Policy

There was a clear official safety management policy coinciding with the marketing management policy in Volvo. The Volvo policy seemed to be interpretable and communicated well through the organization. In SCASA, being a regulator, the whole organization is devoted to safety and it has a clear safety policy on the general level. However, there were some questions concerning problems of interpretations of the safety policy in the organization. In the NPD no explicit safety policy document was analyzed. However, the directorate identifies that "…by regulatory means, to establish, maintain and further develop a responsible safety level and working environment" as one important task of their activities. Also the regulations emphasize strongly that individual participation in the work for safety must be encouraged. Other documents also urge to investments in safety improvements.

In both the automobile and aviation industries it is possible to have stricter safety regulations than the regulator or the law prescribes. In the automobile industry, Volvo was a safety leading company partly inspiring safety measures to the legislator. In the regulated aviation industry, most of the bigger international airlines have their own safety standards on top of national and international regulations. The study on the NPD did not aim at descriptions of individual company safety policies. Petroleum companies will hopefully be treated in a later report.

6.1.3 Feedback

6.1.3.1 Internal feedback and communication

In Volvo, the organizational structure was set up to provide feedback. Of course, some of the important feedback took place informally. The informal communications were made easy because people tended to stay in Volvo (except workers on the line assembling the cars), knowing each other and having their work places in different departments and yet geographically very close. We do not have any specific information about communication problems, but naturally there must have been such difficulties as well. As mentioned above, SCASA showed some signs of not having perfectly communicated boundaries of responsibility. Therefore, some communications were devoted to finding out who was responsible for a specific case or matter, in some cases there were unnecessary overlap of work between different units. The NPD is an example of an organization that makes great efforts in developing their information management. That fact that information management today is integrated and "made visible" as one third of the product areas in the organizational structure, sends strong signals about how seriously they consider this area of safety management. The change to a "paper free" situation, and the funneling of most available information and documentation including some important means for communication to the directorate website, are other examples of engagement in information management. Clear channels of information such as above, are examples of necessary prerequisites for a well functioning information feedback and communication.

6.1.3.2 Incident reporting system

Volvo had an accident reporting system that covered different kinds of accidents. The treatment of these data was kept within the company. There were no regulatory requirements on incident or accident analysis.
SCASA, however, requires incident reports when the severity is of a certain magnitude and encourages incident reporting for all deviating occurrences. These reports can also be anonymous, which supports a positive attitude towards incident reporting in general. In conclusion, the incident reporting attitude is very supportive of reporting both in at least one of the big airlines in Scandinavia and in the regulator. However, small airlines do not have the same resources and might need more attention. Eirevik and Gunnarsson (2003, cf. chapter 3.) studied the feedback given to those who reporting "on the ground incident reports" in a Swedish airport. About one fourth of those reporting felt that they did not get sufficient feedback on their reports underlining the importance of feedback on incident reports.
NPD has a well-developed system for reporting of hazards and accidents. In communications between licensees and the directorate a standardized form labeled "Confirmation of alert/report to NPD about situation of hazard and accident" is used. The forms are available from the website and can be mailed or faxed in to the directorate. There is also a separate form for "reporting of damage on loadbearing structures". The NPD monitors the levels of various safety parameters and uses deviations in stating and reporting the level of safety. The companies' criteria for reporting has recently been put to investigation when there have been indications that some companies have changed their reporting criteria. This is serious since the injury rates become incomparable with raters from previous years

6.1.3.3 Interaction regulated – regulator

Because of the limited scope of the present study, we do not have complete information about the interactions between the regulated and regulating organizations. Therefore, the following has to be based on cues of information that will be followed up in the process of completing the project. However, for civil aviation a separate study was made to investigate the interactions between SCASA and a Swedish airline company. A detailed account for this study is found in the appendix ending this chapter.

Given this reservation, we draw the tentative conclusion that the interaction between SCASA and at least one of the big regulated airlines is quite intense with personal contacts between the two organizations on a daily basis. The regulators and the regulated shared the view on safety, which makes communication easy. There is only a minute part of the resources of SACS devoted to inspections. According to Lindblom et al (2003 ref in chapter 2.) 17% of the resources are devoted to inspections and 420 "in situ" inspections are carried out each year. This in conjunction with the increased competitiveness in the market is a risk for the safety of budget airline companies who do not have their own safety management organizations. Volvo car Company communicated their views on safety and the regulators shared those views making communication easy in 1980.
The interaction between the NPD and licensees was not analyzed. But if we extrapolate on the detailed annual data of various accidents and injuries (separate for contractors and subcontractors) that are reported in documents and continuously updated, we may assume that the interaction is working. In addition to a theoretical amount of communication from the licensee to the directorate another 60000 hours of supervision is reported from the directorate. Together with the previously described standardized procedure for incident reporting and a good information management, it gives more strength to this assumption.

6.1.3.4 Other feedback

Volvo designed a number of external feedback systems themselves, control systems that were cost effective and strict on safety. Most of these external feedback loops were not imposed by societal regulations. The staff of Volvo was highly competent in dealing with *subcontractors*. The staff knew as much as the subcontractors and there was a strict system for controlling safety related details and components. Other feedback systems relevant for the NPD are different cooperative fora that are established. On one hand they are feedback channel-structures that allow communication between the directorate and other actors, but on the other hand, do not necessarily involve structured content of feedback information. If one adopts such a perspective, it may be more constructive to discriminate between established/structured channels for feedback and established/structured content of feedback information, which may exist independent of each other.

6.2 Power – authority

The Safety and Environment department had added authority to their unit through having won all court cases against Volvo concerning safety cases in the USA. SCASA runs the risk of loosing authority if it does not have resources to update its regulations following new developments of technology and work practice. Formal power and authority is clearly expressed in the regulations for the NPD. It comes out quite clear what the directorate controls and also the demands on the licensees. Responsibilities are very obvious and often quite unidirectional. Such a regulations reinforces the legitimacy of power and authority, but puts at the same time less demand on self-monitoring, and identification of weaknesses and needs of improvement in the own organization. This relates partly to the discussions of identified threats below.

6.3 Competence

The competence of the employees in Volvo was at the research and production fronts in relevant fields. The employees tended to stay in the company enabling the company to maintain a very high level of competence in the organization. SCASA has problems with the competence of its staff in the future because of an older staff, relatively poor salaries (in comparison with people in the regulated area with corresponding positions, e.g., pilots) and a disadvantage in location for most of its staff (in the country town of Norrköping). The latter two aspects make it harder to recruit new highly qualified staff when the wave of retirement goes through the organization in some years. The competence in the NPD organization was not questioned here; we assume at this point that also they have made their best efforts in developing the internal competence toward a top level. There are indications that tell us that such efforts have been made. One important indication is the gathering of teams from several disciplines around prioritized products. This is at least one means of rationalizing competence within the organization.

6.4 Integrity

Presently, the airline company investigated has stricter safety standards than those officially required by regulator. Therefore, there is no pressure from this company towards more lax regulation, which could pose a threat towards the integrity of SCASA.

In the Volvo case, the exact degree to which safety management in the Volvo organization was unaffected by influences from other systems inside and outside the Volvo organization is impossible to determine. However, the department seemed quite independent and propagating its views in the organization. However, the Safety and Environment department did not openly oppose the negative environmental effects of using leaded gasoline in Sweden in 1980 (in the USA only cars with exhaust emission cleaning were sold). This seems to represent some kind of influence on the Safety and Environment division to find it reasonable not to insist on elimination this risk factor so early in Sweden. Taking the regulators' perspective, the lead of Volvo in most safety issues might have been helpful, but it might also have hampered regulator initiatives. Volvo was one of the biggest export industries in Sweden at the time, a fact that could, in principle, have had an effect also on the political level, which in turn could influence the regulator, but there were no sign of this.

6.5 Threats to safety management

Financial threats to safety are often most eminent among threats, both in terms of real losses of a company and its consequences on the safety goals, and in terms of a policy of greater profits from an activity/industry. To exemplify, SCASA is a part of the Swedish Civil Aviation Administration SCAA (Luftfartsverket) who is financed by fees paid by the airlines. SCAA owns and runs airports and including several services related to aviation. In times of financial pressure on the airlines with a deregulated market, this becomes coupled with a smaller income for SCAA and wish to decrease the costs of SCASA. This is an unfortunate coupling in which two links in a safety management chain are weakened from a common cause (deregulation).

Of course, most of the time the focus in safety management is directed towards the regulated activity/industry and not towards the regulating organization itself. However, like other organizations there are threats in the form of loss of resources (e.g., funds, competence) lack of internal development strategies towards maintaining and improving the organization's own management to the benefit of the regulated organization's safety management etc.

In the Volvo Case, the owners did not push uniformly for maximum financial return before 1980, but allowed the general managers to prioritize safety as long as the company kept on delivering a reasonable profit to the owners year after year. However, the situation has changed and now the future may include financial threats (e.g., in terms of policies to maximize profit) to the earlier heavy prioritization of safety.

There was another threat mentioned against SCASA in that the authority was unable to update regulations (because of quickly changing conditions in the aviation industry). The low rate of inspections (420 "in situ" per year) was mentioned as another threat against the effectiveness of the safety management in SCASA. There are many thousands of pilots in Sweden and this means that a pilot could work for 20 years without ever having had an inspection. Insufficient resources and/or management of resources posed another threat: inspections of some particular kinds of lower priority systems or activities (e.g., systems used for transatlantic flights) have not been conducted at all lately.

The NPD identifies mainly internal threats in companies. The threats identified are considered urgent and are of various kinds including technical, but also organizational and cultural threats. Two lethal accidents the previous year gave additional impetus to the safety work. The documents we had in hand gave not much information about how the directorate views threats to safety management in the own organization. One probable reason to this is related to the discussion (above) about the authorities main task, namely, to "regulate the regulated". The other way around is probably seldom the case.

One external threat directed towards the NPD is indications of declining petroleum production over the coming years. The directorate takes this threat seriously and identifies a number of future scenarios as results of different approaches to resource management. Here, the problem focus is partly directed towards decreasing future incomes and the following consequences of reduced GNP. However, in is important to note that the directorate's economy is part of the Norwegian petroleum incomes, in turn directly related to the directorate's own budget. Reduced national oil incomes will probably affect the industry in several ways, such as the companies as well as the authorities economical premises for their safety work. This is a possible future threat to the Petroleum directorate. This is a threat that NPD probably shares with other agencies that are more or less dependent on the economies created by the industries they inspect.

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